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EDITORIAL

SEED SELECTION AND RUBBER.

THERE is a more or less widely-held belief that the seed produced by a proved clone planted in an isolated seed garden will, of necessity, give rise to high yielding trees; and it has apparently been assumed in certain quarters that the planting of proved buddings in a sufficiently large area of seed gardens will alone solve the problem of providing an adequate supply of high-yielding material. It is unfortunate for the rubber industry that there is no foundation for this belief. A knowledge of genetics and of the pollination of the rubber flower shows that it is untenable. Rubber is normally cross-pollinated and it will be only under exceptional circumstances that a rubber seed will contain the factor for high yield, or the complex of factors determining high yield, in a genetically pure form. Normally, rubber will be what is known as heterozygous for many or all factors which make up its genetic composition, and the segregation of pure lines will be a lengthy and complicated process.

These points are clearly stated by Mr. F. Summers in his excellent manual on the budding of rubber which has lately been published by the Rubber Research Institute of Malaya. He states:

> Budding will be essential for the establishment of isolated seed gardens but it is often mistakenly assumed that if buddings from a single mother tree are planted in such a garden the resulting crop of seed will have the special high-yielding properties of the original mother tree.
>
> This is not the case: the assumption is based on a false analogy with cereal plants which are normally self-fertilised. To start a pure line of high-yielding Heveas two requirements are essential; first, a parent which is genetically pure with respect to the character for high yield and, secondly, self-fertilisation of the mother tree or cross-fertilisation of buddings taken from

it. The second requirement can now be easily satisfied but we are far from being able to satisfy the first. Our knowledge of the heritability of yield is almost nil and it is essential that this consideration be borne in mind if waste of effort and enthusiasm is to be avoided.

The process for the isolation of lines carrying the factor or factors for high yield in a pure form will probably be essentially as follows. Buddings from a proved mother tree (or perhaps even from an unproved mother tree, for the relation between the sexual and asexual inheritance of similar factors is not yet known) will be planted in an isolated seed garden. The seed from this garden will correspond to what is known in plant breeding as F 1 seed. In effect it is the selfed seed of the mother trees. This seed will be planted, preferably in a central research station, and will give rise to an F 2 generation which will be a mixture of many types, a certain proportion of which will contain, pure or impure, the factor or factors for high yield. Tapping tests will determine, but not with the precision to be desired, the high-yielding trees. A number of these higher-yielding trees, depending on practical considerations of space available, say ten or twenty, will be each asexually propagated by means of buddings in a further ten or twenty isolated seed gardens. The seed from these second-series seed gardens, in effect F 2 seed, will be planted separately, again in a central research station, and each tree of the ten or twenty progenies will be tapped. The tapping results will show to what extent segregation is still taking place, in other words, if any of the ten or twenty seed gardens are pure lines. It is to be hoped that out of the ten or twenty seed gardens one or two at least will be carrying, pure or sufficiently pure, the factor for high yield. Such a pure line can be rapidly multiplied by means of budwood nurseries and further seed gardens. At the same time it has to be noted that, although seed selection in a series of isolated seed gardens will not produce for many years a strain which is 90 per cent. pure for the factors determining high yield, nevertheless it may be possible to put the seed of earlier (and less pure) seed gardens to commercial use by planting it thickly and by thinning out after tapping tests.

But if seed selection is long and laborious it is nevertheless an avenue of research to be investigated closely. Rubber is supposed to be normally self-sterile, but if it is found possible to bring about self-pollination by bagging a large number of flowers of the same tree in one bag the process of seed selection will be hastened by four or five years. Attention may be drawn to the paper on the pollination of rubber which is reproduced in the present number, and it is worth while to emphasise the fact that in Sumatra seedlings resulting from the crossing of two mother trees have given yields higher than either of their parents. Hybridization followed by the asexual propagation of successful crosses may have tremendous possibilities.

ORIGINAL ARTICLES.

THE EFFECT OF NITROGEN ON THE YIELD OF RUBBER.

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IN *The Tropical Agriculturist* of November, 1928 the writer published an account* of a statistical examination of the results of the "Old Manurial Experiment" which was carried out at Peradeniya during the years 1914-1927. It was stated there that "the fact that the nitrogen and general mixture plots which started at a lower level than the control plot have steadily increased in yield and have finally exceeded the yield of the control plot is strong presumptive evidence that the differences in the mean yields of the plots, statistically significant, are in reality due to the treatments associated with these plots and not due to the fortuitous circumstances of initial soil fertility." The method of statistical examination employed was not capable of directly proving that the increases obtained from the "general mixture" and "excess of nitrogen" plots were really due to the manurial treatments although there was little doubt that this was so. A method of direct proof, however, is available and has recently been used by Eden† in examining the effect of lime on tea. At the suggestion of Mr. Eden this method of making use of the regression coefficient has now been employed to re-examine the yields of the control and nitrogen plots as the average increase given by the nitrogen plot was appreciable and, under certain conditions, profitable.

The value of the regression coefficient for the two series of yields for the whole period of the experiment is + ·1085, and this figure is definitely significant as the odds against its being due to chance are more than 100 to 1. The conclusion, therefore, is that the nitrogen plot has *gained* on the control plot at the rate of ·1 lb. per year and that this gain is due to the manurial treatment. This figure of ·1 lb. shows the cumulative effect of the manure over a period of fourteen years. The mean average increase of the nitrogen plot over the control plot is ·5 lb. and it is this figure which should be used in judging the profitableness of the treatment. It is quite possible that the cumulative effect of the manure had not ceased in 1927 when the experiment was discontinued. Before any definite pronouncement can be made on the economics of nitrogen and other manuring for rubber a more precise experiment will have to be conducted. It has been arranged to do this at

* Manuring Experiments and Experimentation with Rubber, pp. 263-271.
† Eden, T. Co-operative Liming Trials. *Tea Quarterly*, II, 1929.

Peradeniya from the end of this year. There is now, however, valid evidence that nitrogenous manures increase the yield of rubber at Peradeniya.

The calculation of the regression is given at the end of this note. The notation used is that given by R. A. Fisher in his "Statistical Methods for Research Workers" pp. 114 to 123 (1st Ed.).

It is a pleasure for the writer to express his indebtedness to Mr. T. Eden for advice and assistance.

CALCULATION OF REGRESSION COEFFICIENT.

(Yield of dry rubber in lb. per tree).

Year x (i)	Control Plot (ii)	Excess Nitrogen Plot (iii)	(iii)-(ii) y	y^2*	Cumulative Sum Column
1914	2·69	2·37	— 0·32		6·99
1915	3·62	3·50	— 0·12		7·31
1916	4·00	3·87	— 0·13		7·43
1917	4·00	4·44	+ 0·44		7·56
1918	3·81	4·50	+ 0·69		7·12
1919	3·87	4·50	+ 0·63		6·43
1920	4·94	5·20	+ 0·26		5·80
1921	4·31	4·50	+ 0·19		5·54
1922	4·75	4·62	— 0·13		5·35
1923	4·44	5·25	+ 0·81		5·48
1924	5·44	7·06	+ 1·62		4·67
1925	5·44	6·06	+ 0·62		3·05
1926	5·50	6·06	+ 0·56		2·43
1927	5·44	7·31	+ 1·87		1·87
Totals			+ 6·99	8·7963	77·03
Mean			+ 0·4999		

$$S(x-\bar{x})^2 = \frac{n'(n'^2-1)}{12} = 227{\cdot}5$$

$$S\left\{y(x-\bar{x})^2\right\} = 77{\cdot}03 - 52{\cdot}425 = 24{\cdot}605$$

$$b = +\,{\cdot}1085$$

$$S(y-\bar{y})^2 = 5{\cdot}2977$$

$$b^2 S(x-\bar{x})^2 = 2{\cdot}6777$$

$$S(y-Y)^2 = 2{\cdot}62$$

$$s^2 = {\cdot}2183$$

$$s^2/S(x-\bar{x})^2 = {\cdot}0009597 = \sigma^2$$

$$\sigma = {\cdot}03098$$

$$t = \frac{b}{\sigma} = \frac{{\cdot}1085}{{\cdot}03098} = 3{\cdot}502$$

$$n = 12$$

* Total only given.

MYCOLOGICAL NOTES (17).

A SCLEROTIAL DISEASE OF PENTAS CARNEA BENTH.

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IN October 1928, a number of full grown plants of *Pentas carnea* grown in a bed in the economic nursery of the Royal Botanic Gardens, Peradeniya, was found to be diseased. The roots and lower portions of the stems were not affected and no plants were found which had been completely killed. Lesions were present on the stems, at first crimson red, then purple to dark-purple and sunken, with a distinct, thin, dark reddish-brown margin. On the leaves diseased patches, purplish-green on the upper surface and reddish-brown on the lower surface, were present and the diseased tissue was separated from the green healthy tissue by a distinct margin on the upper surface. Fungus hyphae were present over the surface of the diseased plants, on leaves, shoots and stems. A silky, pale-brown web of mycelium completely enveloped the green stems. Sclerotia of a fungus were found scattered over the diseased areas. These bodies were purple-brown in colour, pitted, irregular in shape, flattened usually at the point of attachment, small and attaining a diameter of about 0·5 millimetres. They occurred singly or grouped together and were also found on the hyphae which ran along the green healthy stems. In shape and external characters they resembled the sclerotia of *Rhizoctonia Solani* as found on *Dolichos Hosei* (*Vigna oligosperma*), paddy, maize and groundnut but were smaller. The superficial hyphae were hyaline or light-brown in colour, branched and from 6 to 11 microns in diameter. Where a branch was given off from a main hypha the base of the former was usually constricted. A loose net-work of hyphae was present on the lower surfaces of the diseased leaves. These hyphae were of the same dimensions as the superficial hyphae on the stems but had short septate branches.

The fungus appeared to spread from plant to plant by contact. No fructifications were found.

CULTURES.

In order to establish a connection between the superficial hyphae on the stems, the sclerotia found on the surface and the hyphae on the lesions, fragments of diseased tissue underlying the lesions, the hyphae on the stems and individual sclerotia were

taken into culture on maize meal agar. Pure cultures were obtained and in every case the hyphae grew adpressed to the surface of the culture medium forming a strong superficial film of mycelium. Sclerotia were produced in about five days. The hyphae varied in diameter from 6 to 12 microns with the typical *Rhizoctonia* constriction of the branches at the point of origin. As the culture became older the medium changed from a white colour to dark-brown due possibly to the hyphae in old cultures turning brownish. The sclerotia varied in diameter from 0·5 mm. to 4·0 mm.; a few were typically pitted but the majority were covered with a loose felt of matted hyphae. They were produced singly on the surface of the culture medium and on the hyphae which had ascended the sides of the culture tube or were aggregated to form irregular masses. In section they showed no differentiation into cortex and medulla, the pseudoparenchymatous structure being uniform throughout.

INOCULATIONS.

Inoculation experiments were carried out on the leaves, stems, and shoots of well-grown *Pentas carnea* plants in order to test the parasitism of the fungus. Seedlings of French bean (*Phaseolus vulgaris*), cow-pea (*Vigna catjang*) and cotton (*Gossypium* sp.) which have been proved to be susceptible to the attack of *Rhizoctonia Solani* isolated from *Vigna*, paddy and groundnut (1) were also inoculated with the *Pentas* fungus in order to ascertain whether the latter fungus resembled the other strains in pathogenicity.

1. *Pentas carnea* plants were obtained apparently free from disease and established in pots of sterilised soil in the laboratory. The pots were placed in a glass cage and the plants were inoculated. A culture on maize meal agar containing growths of hyphae only was mixed with distilled water and drops of the mixture were placed on the leaves, flowers, shoots and stems. Two days after inoculation, the points of inoculation of the leaves, flowers and shoots turned black in colour, the hyphae having invaded the tissues and set up a rot. On the following day greenish-brown spots were numerous on the leaves and greenish-brown patches were formed by the coalescing of individual spots. Two days later the leaves which had turned dark-brown or almost black were practically dead and the green stems were enveloped by a film of mycelium similar to that on the diseased plants in the nursery. The control plants which remained healthy were now inoculated by placing diseased leaves of *Pentas* picked from the nursery in contact with healthy leaves. Possitive infection was observed after six days. Heavily infected plants were taken out of the inoculation chamber and placed under shade in the open. In about a fortnight's time the plants appeared to have shaken off the disease and produced new shoots below those which were killed.

2. French bean seeds were sterilised in corrosive sublimate solution and sown in pots of sterilised soil. Fifteen seeds germinated. The seedlings were about five inches high after eight days, and at this stage stem inoculations were made on eight seedlings by placing a piece of maize meal agar culture containing growths of hyphae in contact with the stem at ground level. After inoculation the pots were placed in a glass cage. After five days a brownish discoloration appeared at the points of inoculation of five seedlings and a yellowish liquid was exuded from the discoloured areas. On the evening of the same day the seedlings collapsed. On the following day the remaining three inoculated seedlings behaved similarly. Six days later infection spread by contact to three of the uninoculated control seedlings. The control seedlings in another pot remained unaffected.

3. Cotton seeds were surface-sterilised similarly and sown in pots of sterilised soil. Fifteen seedlings about two to three inches high ten days after sowing were inoculated by placing pieces of culture medium containing hyphae in contact with the stems at ground level. In three days the stems at the inoculated points turned pale yellow-brown and five seedlings collapsed at the discoloured areas. Drops of pale-yellow liquid were exuded from the diseased areas. In another three days seven more seedlings collapsed. The remaining three seedlings became typically discoloured at the point of inoculation but were not killed, the lesions drying up.

4. Seedlings of cowpea (*Vigna catjang* var. *sinensis*) were inoculated at ground level in a similar manner. All were infected after three days.

THE FUNGUS.

The mode of growth of the *Pentas* fungus in culture on maize meal agar and the morphological characteristics of the hyphae and sclerotia were identical with the mode of growth and the morphological characteristics of *Rhizoctonia Solani* from *Dolichos Hosei*, paddy and groundnut when grown on the same medium (1).

The sclerotia of *Rhizoctonia Solani* from *Pentas* in nature were smaller than those of the same fungus occurring naturally on the other plants named above. In pathogenicity the *Pentas* strain resembled the other strains and was shown to be capable of attacking French bean, cowpea and cotton seedlings and of causing them to damp off.

CONCLUSION.

Rhizoctonia Solani is here recorded as the cause of a leaf and stem disease of *Pentas carnea*. Inoculation experiments demonstrate that the fungus can attack the leaves, flowers and shoots of the plant, but that it does not usually kill the plant. As no fructification of the fungus *Corticium vagum* was found on the stems and

leaves it was assumed that infection had occurred from sclerotia in the soil. It is possible that infection may have taken place by wind-blown spores of *Corticium vagum* from another source.

Gadd and the writer (1) during the course of the inoculation experiments which they carried out with this fungus noted that the fungus was very susceptible to moisture conditions and that infection occurred readily when atmospheric conditions were moist. Conditions which were ideal for the fungus were found in the nursery which was situated on flat land, shaded on one side by a row of big trees, and in which the *Pentas* plants were very closely planted in a bed.

Cutting off and burning diseased stems and leaves of *Pentas* affected with the fungus, the collection of fallen leaves found on the bed and thinning out the plants should reduce the attack considerably.

REFERENCES.

1. Gadd, C. H. and Bertus, L. S.—*Corticium vagum* B. and C. The cause of a disease of *Vigna oligosperma* and other plants in Ceylon. Ann. Roy. Bot. Gardens. Peradeniya (The Ceylon Journal of Science), XI, pp. 27-49, 1928.

MYCOLOGICAL NOTES (18).

GERANIUM STEM ROT CAUSED BY PYTHIUM SP.

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WHILST taking geranium cuttings recently the writer found a plant affected by a stem rot. At the junction of two branches, just at soil level, the tissues of the stem were blackened and rotted, and a large lesion due to mechanical injury indicated the point of entry of the invading organism. The branch was removed, and a second cut made at a node six inches above the first showed the tissues here also to be rotted, although there was no external sign of injury beyond the original lesion. On splitting open the stem the central pith was found to be dark green and soft, and microscopic examination showed that it consisted of a mass of individual cells with shrunken walls and no apparent contents beyond starch grains, which were numerous and prominent. Running among the cells were fungus hyphae, narrow and with many oil drops, and it was apparent that the condition of the pith was due to the absorption of the middle lamellae of the cells by an enzyme secreted by the fungus. The cut surface darkened rapidly on exposure to the atmosphere. The xylem cylinder and cortical tissues were not affected, which accounted for there being no external symptom of disease at this point.

Portions of diseased tissue taken into culture produced pure growths of a species of *Pythium* allied to, if not identical with, the fungus which is responsible for "damping-off" of seedlings in nurseries. Braun (1) records a stem rot of geranium due to *Pythium* and it is evident from his paper that the present case was taken in the early stages. The disease he describes is common on cuttings. The cutting fails to root, the base turns black and rots, the affection spreads up the stem and generally

results in the blackening of all the stem tissues and the death of the cutting. Several species of *Pythium* are held responsible for the disease (the symptoms are too closely similar to allow of their being justly separated into "diseases") but is not intended to enter here into a discussion of the merits of the various species of *Pythium* concerned. The author unfortunately fails to suggest control measures beyond stating that in cases of attack by *P. complectens* the progress of the disease is eventually stopped by the formation by the plant of a cork cambium which delimits the diseased tissue and arrests the advance of the fungus. Buddin and Wakefield (2), however, suggest soil sterilisation, the burning of diseased material and the avoidance of excessive moisture, the treatment which is given in cases of "damping-off."

REFERENCES.

1. Braun, H. Geranium stem rot caused by *Pythium complectens*, n. sp. J. Agr. Res., XXIX, 8, 1924, p. 399.

2. Buddin, W. and Wakefield, E. M. Black leg of *Pelargonium* cuttings. Gard, Chron. (III) LXXV, 1924, p. 25.

FIG. 1

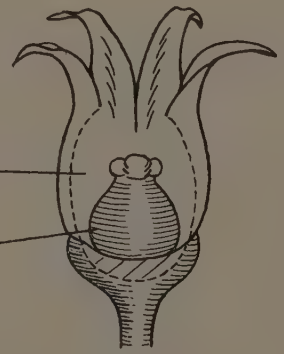

FIG. 2

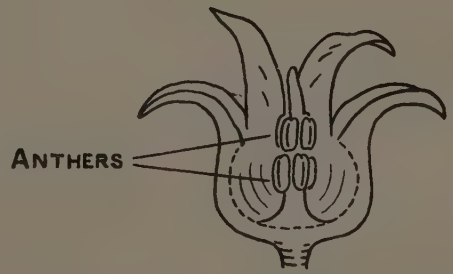

FIG. 3

BLOCK BY SURVEY DEPT. CEYLON.

SELECTED ARTICLES.

FIELD OBSERVATIONS AND EXPERIMENTS ON THE POLLINATION OF HEVEA BRASILIENSIS.*

1. INTRODUCTION.

IN the improvement of a crop by selection or breeding the first steps to take are to study the natural methods of production of the plant concerned and to find out how far the individuals already in our fields display the character we desire to intensify and preserve, so that the most suitable stock for selecting or breeding from can be chosen.

With Hevea we wish to grow trees that will yield large quantities of rubber and also possess the advantageous characters of disease resistance, suitable tree shape and so on. It is well known that the bulk of the crop from any particular field comes from only a small proportion of the trees and it is from such high yielders that we must generally start in any attempts to improve the general standard of plantation rubber, whether by budding, seed selection, or the breeding of new and better types.

It is with the last of these methods that the present note is concerned.

2. THE STRUCTURE OF THE FLOWER AND THE DEVELOPMENT OF THE BUD.

During the flowering season the rubber tree produces masses of flowers, which are borne in bunches (inflorescences) towards the end of the leafy twigs where the new season's growth is starting. Each inflorescence is much branched and bears two kinds of flowers. The female flowers are situated at the ends of the central axis and of the main side branches, while the male flowers occur in much greater numbers on all the lesser shoots as indicated in the much simplified diagram (figure 1). The flowers of both sexes are surrounded by a bell-shaped corolla of usually five yellowish petals. The female flowers can be distinguished not only by their terminal position but also by their greater size and by the small green button-like expansion at the base of the petals. When the bud opens the round green ovary can be seen inside carrying on top three whitish lobes. These are known as the stigmas and form the receptive portion of the female sexual apparatus; fig. 2 shows a diagrammatic sketch of a female flower cut through longitudinally. The male flower is yellow right down to its stalk, and an opening exposes a central white slender column surrounded by two rings of tiny yellowish rounded projections. These are the anthers, which soon split and set free the pollen as a slight yellow dust. (A section of a male flower is shown in figure 3.) The pollen grains carry the male generative cells and if transferred to the stigmas under the proper conditions (pollination) they may germinate and fertilise

* By L. E. Morris in *The Quarterly Journal* of the Rubber Research Institute of Malaya, Vol. I. Nos. 1 and 2, January, 1929.

the female. Subsequently the ovary will grow and become a fruit containing three or, rarely, more seeds. The whole of the woody fruit wall and the outside layers of the seed, including the hard outer coat with its characteristic colour and markings and shape, arise from purely female tissue, and, though development does not take place without fertilisation, no male substance enters into them. The embryo, which lies in the middle of the seed and later grows into the seedling, is, on the other hand, the direct product of fusion between the male and female germ cells, and inherits a mixture of the characters of both parents.

3. THE NATURAL POLLINATION PROCESS.

The method by which the natural pollination of the flowers is brought about determines the parentage of the seeds, that is whether they are the offspring of but one tree or of two different parent trees.

Two general types of pollination occur in plants that have separate male and female flowers. In one of these the pollen is transferred from the stamens to the stigmas by wind, and in the other by insect visitors. The structure of the flower of Hevea, the stickiness of its pollen and stigmas and the presence of an attractive scent and colour indicate that insect pollination is the most probable method, although so far positive evidence from actual observation is lacking. Many kinds of insects may be seen flying round the inflorescences, and several workers in the Dutch East Indies have observed the flowers being visited by bees, flies, moths and beetles of several families, but they do not state that these insects were actually seen to enter female flowers.

During the flowering season of 1928 the same families of insects have been seen on Hevea inflorescences in Malaya. Three or four sorts of bees have been frequently watched while visiting the male flowers for pollen and have then been captured and examined. The baskets on their legs have been observed to be filled with pollen, which under the microscope has been indentified as that of Hevea. Nevertheless, so far, not one has been seen to enter a female flower, the nearest cases being two which paused on the edge and then turned away.

Smaller numbers of bugs, caterpillars, weevils, ladybirds and other beetles, flies and ants have also been observed. The bugs and weevils may puncture the flowers, and the caterpillars and some of the beetles eat them but the ants appear to take no interest whatever in the flowers. Occasionally flies have been seen entering male flowers, but the only insects seen with certainty in a female flower have been two minute beetles and one tiny fly, which walked all round the petals without touching the ovary and so could not have carried pollen to the stigmas. It appears probable, nevertheless, that the more numerous and active bees are responsible for pollination.

The part played by insects in general has been demonstrated, in the Dutch East Indies by Maas and now in Malaya, by covering inflorescences with muslin bags to keep out insects and so preventing the flowers from setting fruit. In the course of pollination experiments that were started on Pilmoor Estate, Batu Tiga, Selangor, in the first flowering season of this year over thirty inflorescences with about two hundred female flowers and very many more males were enclosed in insect-proof bags and not one fruit was formed.

It might appear that the right insects for pollinating Hevea are not present in the East, for though the rubber tree produces such a mass of blossom very few female flowers develop into fruit. For example in Java

Mass found that only 2% to 3% of female flowers set seed—in one series of observations 20 out of 927—and Heusser says that on the average only one fruit forms for seventy-two female flowers.

4. ARTIFICIAL POLLINATION.

If insects do actually pollinate Hevea it is possible that when collecting pollen they will visit several trees in one excursion, and so the female flowers may receive pollen from males on the same or other trees. In that case seed picked from one tree will have a known mother but its male parentage will be unknown. For accurate breeding experiments, however, it is essential to know both parents and recourse must be had to artificial pollination.

In the method used this year on Pilmoor Estate suitable inflorescences were selected and all open flowers removed. If the females were to be used all the male buds were cut off also, lest they should open later and their pollen reach the female flowers during subsequent handling. The prepared inflorescence was enclosed in a muslin bag supported on a light wire frame and left until the flowers began to open. Male flowers from another tree were taken to the mother tree and the bag opened temporarily, so that the anthers could be picked out with sterile forceps and transferred to the stigmas of the female flowers, which were enclosed again for a few days until the petals had withered and the stigmas had turned brown, showing that they were no longer suitable for the reception of the pollen.

After carrying out these operations everything may be left to proceed naturally. If pollination has not been successful the female flower withers and falls within two or three weeks but if fertilisation has ensued the ovary begins to grow slowly at first but more rapidly during the second month, until, unless previously damaged or diseased, it reaches full size after two and a half or three months (fig. 4). Internal growth and development of the seeds then goes on and the fruit ripens about two months later.

5. BREEDING METHODS.

With both plants and animals breeding methods generally fall into the two classes of "inbreeding" and "crossbreeding". In the first method individuals that possess the desirable characters in the highest degree are alone chosen as parents. The type is then purified by breeding only from close relations, as with animals, or in most plants between different flowers on the same plant or even from one flower alone. From each generation only those offspring that come nearest to the desired type are selected and used as parents for the next. Thus at each step the characters sought for are intensified, until after a few generations a strain is obtained that will breed reasonably true to type. It must be remembered, however, that no new hereditary factors can be brought in by this method, and if the full expression of a certain character is determined by the combination of several inherited factors (and many such characters are known in genetics) but all are not present in the original parents, then no amount of continued inbreeding will produce a race with that particular character developed to the fullest possible extent.

If, however, cross breeding is employed between parents possessing different hereditary constitutions one of them may carry one or more of the determining factors not present in the other, and when these sets are re-combined in the next generation some of the seedlings may inherit the complete set and so exhibit the greatest possible development of this character. Subsequently the new strain may be preserved by inbreeding and continued selection.

It is very probable that the latex yielding capacity of Hevea is a complex character determined by all the hereditary factors that influence latex vessels, girth, quality of latex and so on, and thus one high yielding tree may be genetically different from another, neither having a complete set of factors and neither being the best ultimately possible.

6. EXPERIMENTS IN SELF-POLLINATION.

With the limitation just mentioned selfing gives the quickest route to the production of a uniform race; but in the case of Hevea this could not be accomplished quickly as each generation takes several years from seed through tapping tests to seed again. The greatest drawback, however, is that not all Hevea trees are suitable for this method of breeding for most appear to be self-sterile, *i.e.*, pollen from the male flowers will not fertilise female flowers on the same plant.

Maas and Heusser in the Dutch East Indies have published the results of experiments in self-pollination and their successful pollination in 1919 and 1920 respectively averaged 1·7 and 0·8 per cent. of their attempts, and though one tree gave as much as 6·9% of success, nine out of the fifteen studied gave none at all.

Heusser states, however, that in some cases the sterility of the mother tree was lost to some extent between its budded offspring and pollination became successful. Unfortunately this does not occur always. During May and June of this year two of the highest yielding budded clones A 44 and B 58 on Pilmoor Estate were tested for self-sterility. Flowers on a number of trees were pollinated from other trees in the same clone and from male flowers on other parts of the same tree or on the same inflorescence. Altogether 154 flowers of A 44 and 255 of B 58 were pollinated but without a single success.

7. CROSSING EXPERIMENTS.

Experiments on cross pollination have been carried out for several years in Sumatra, and they show that, so far as raising seed is concerned, crossing gives better results than selfing.

In 1919 Maas obtained 42 fruits from 751 cross pollinated flowers, that is 5·6% of successes. The results varied greatly from tree to tree; for example trees No. 4, 5, 6, and 7, gave about 2, 4, 13 and 12% respectively. In 1920 Heusser and his assistants achieved 10·9% of successes from 6716 cross pollinations. With 35 different combinations of 20 parent trees the results again varied greatly. For example in the cross between tree 29 used as the mother and 141 as the father out of 239 pollinations the whole failed. At the other extreme when trees 138 and 146 were employed as the female and male parents respectively 83 successes out of 211 or 39·3% were obtained.

The fruit setting of one mother tree also depended on the father: tree 164 gave no successes with pollen from tree 144, but gave 8·9% with tree 142 while, when tree 151 was the male parent, 28 fruits were harvested as the result of 132 pollinations, *i.e.*, 21·2% success.

In 1925 Schweizer in West Java made 18% of successful crossings, 187 out of 936, and van der Hoop in Java gives his total results as 5% in 1924, 35% in 1925, 8% in 1926 and 6·9% in 1927.

In May and June of this year cross pollination was carried out on Pilmoor Estate between the clones A 44 and B 58. From 143 female flowers of A 44 two fruits are now ripe, and from 260 crosses with B 58 as the mother one fruit only was obtained, that is less than 1% of the

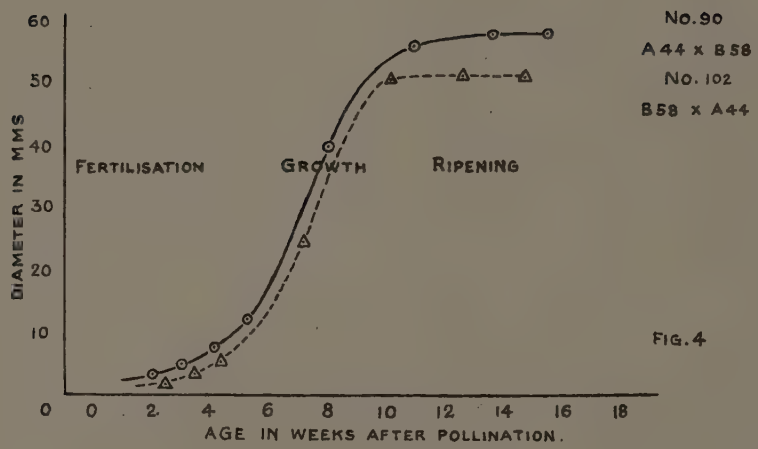
No. 90
A 44 x B 58
No. 102
B 58 x A 44
FERTILISATION
GROWTH
RIPENING
DIAMETER IN MMS
AGE IN WEEKS AFTER POLLINATION.
0
10
20
30
40
50
60
0
2
4
6
8
10
12
14
16
18

FIG. 4

pollinations were successful. To illustrate the mortality amongst young fruit, and the uncertainty of results in work of this kind, it may be of interest to follow the hopes of success from these two crosses. Growth of the ovary into the young fruit is first noticeable between two and three weeks after pollination. From 143 flowers of A 44 only six ovaries had started to grow in three weeks, and were then about 3 mms. in diameter. Inflorescence No. 49 formed two young fruits of which the lower dropped off in five weeks and the other in seven weeks. The one fruit on inflorescence No. 50 grew well to 14 mms. in seven weeks, but then its stalk was broken by the wind and it was dead a fortnight later. On inflorescence 90 two young fruits were growing three weeks after pollination and both have survived. The continuous curve of fig. 4 shows the growth of one of them from the time it was first measured at 2½ weeks after pollination, through the slow growing period and then through the time of rapid growth (from about 6 to 10 weeks) to the final stage of constant size when ripening is proceeding.

Of the reciprocal cross, in which the female parent was B 58, only 3 out of 260 flowers pollinated were alive three weeks later. The one on inflorescence 97 died during the next week, that on No. 96 grew to 5 mms. and withered between 6 and 9 weeks and only the fruit on inflorescence 102 grew till it reached its full size of 53 mms. in eleven weeks. The growth of this fruit for fifteen weeks is indicated by the dotted curve in fig. 4 and it is of very great interest to note how this also shows the influence of the mother tree on the size of the fruit, for after natural pollination also B 58 fruits are smaller than those of A 44.

Thus of the seven young fruits that were growing one month after pollination only three survived and reached full size. In addition it still remains to be seen whether their seed will be fertile and germinate.

Having emphasised the casualties that have to be reckoned with it may be permissible to quote the apparently greater success of some of the later crosses made in the second flowering season in August in further illustration of the tree to tree differences previously obtained by Heusser. From 261 female flowers of Clone A 8 crossed with A 44 16 young fruits have survived for five weeks. The four oldest have now lived for seven weeks and are about 18 mms. in diameter. Of the 39 flowers of A 44 crossed in the reverse way all have died though one was still growing at three weeks. Other combinations of clones are still more hopeful. For example four weeks after pollinating 57 flowers of A 44 with D 61 pollen ten young fruits are alive, while the reciprocal cross has given about twenty potential successes from one hundred pollinations. Thus even allowing for severe casualties these crosses promise to be considerably more productive of fruit than those betwen A 44 and B 58, though on the other hand one or two others probably will be even less successful.

It is obvious that much more remains to be learned about the conditions necessary for success before a sufficiently satisfactory procedure for estate work can be recommended, but, on the other hand, it is distinctly encouraging that such a degree of success has attended the first efforts in this direction.

Although better results are obtained from artificial crossing than in nature or by selfing, still many female flowers have to be pollinated in order to obtain a few fruits. Various attempts have been made to find a method of increasing the chance of success or explaining the failures. Schweizer considered that his experiment was affected by the weather, and van der Hoop's variations from year to year taken with known results for other

crops suggest that weather may exert a large influence. For instance, the time of day at which the flower buds open and at which the pollen is set free is affected, and is later on a dull and moist day than on a bright and dry one.

Maas studied the effect of pollinating at various stages of opening and, on th whole, obtained the highest success by using male and female flowers on the morning after opening, less from just opened flowers, and least from females at the midday after opening with the use of fresh pollen. With one tree, however, these last conditions gave better results. The differences were, nevertheless, not great enough to balance the practical difficulty of using flowers at one stage only, for this reduces the number of pollinations that can be made, and any such programme is very liable to be upset by rain. It is hoped to obtain additional evidence on the effect of the conditions under which pollination is carried out from the results of this year's work on Pilmoor Estate, in which now over 2,200 flowers of 8 clones have been pollinated in all possible stages.

The hopeful possibilities of crossing as a means of producing high yielders are illustrated by Heusser's results in Sumatra. Twenty seedlings from a cross made in 1919 between trees 36 and 35 averaged 11·2 grams per tapping in their first tapping period from May 1924 to October 1925, as compared with 8·7 grams for Clone 35, that is, for buddings from the male parent of the cross. The best seedling gave 21 grams and the best budded tree only 14, while the seedlings have maintained their superiority in subsequent years. The best trees have been multiplied by buds, marcots and further crossings so that now tapping results are being obtained from a second generation cross made in 1923.

LATEX TUBE BORE.*

ON Monday, 3rd December, 1928, Mr. H. Ashplant, the rubber specialist, United Planters' Association of Southern India, gave a lecture in the R. G. A. Council Room on his recent discoveries. The lecture, which was followed by a microscopical demonstration, was attended by members of Council and Directors of South Indian Companies, subscribers to the South Indian Rubber Research work. The following is a report of the lecture and discussion :—

Commencing with a discussion of the causes underlying yield variations, Mr. Ashplant stated that all attempts to express yield values in terms of latex ring number had been unsuccessful. Rubber investigators generally had fallen back on physiological explanations. They were encouraged in this by their failure to correlate yields at different heights in the tree with the number of latex rings at these heights.

In 1926 he, the speaker, had cleared up the last-named mystery. Investigations in South India had shown that the reason for apparent lack of agreement between the number of rings and the yields at various levels was the differing proportion of the total number of rings tappable at different levels. When only the rings in tapping were compared, one found that a remarkably close relation existed between yields and the number of rings.

No one seemed to have appreciated the significance of this work, which, in the speaker's view, rendered the assumption of physiological differences unnecessary, for, if the anatomical facts fully explained the yields at different heights in the same tree, it was reasonable to expect that a more detailed knowledge of the latex-producing organs would go a long way to explain the differences in individual tree yields.

LOGICAL BASIS OF THEORY.

Physiological theorists had entirely overlooked one point, and that was the necessity for accommodation. Even granting the laticiferous elements, in some trees to be more active in synthesising latex than those of other trees, the accommodation of the latex still had to be provided for. The latex is produced and stored entirely in the latex tubes and, being a gross substance occupying space, more latex meant more containing capacity, *e.g.*, either more latex rings or larger latex tubes. There was evidence that the ring mesh of the latex tubes varied in density, but this seemed to have a small influence only.

Accommodation being so necessary, it was therefore clear that when the number of latex rings in a tree would not account for its higher or lower yield compared with other trees, one was driven to infer that the latex tubes themselves were of larger or smaller bore. This was only elementary logic.

It would be a long story to relate the investigations in detail, but as long ago as 1923 he had obtained evidence of the existence of tube bore differences. The measurement of latex tubes was then, however, surrounded by immense difficulties, and the results obtained frequently confusing. After several years' work, during which time he carried out a systematic exploration of the latex tubes, studying them and measuring them

* Reprinted from *The Bulletin of the Rubber Growers' Association*, Vol. 10, No. 12 December, 1928.

ring by ring from root-tip to leaf-tip in six trees, the reason for the confusing results was made clear. Owing to the tangential stresses due to secondary growth, the tubes are distorted, with the result that the diameters of the tubes, as seen in tangential sections, become progressively greater with distance from the cambium. This fact renders comparisons between the latex tubes in different trees exceedingly difficult and unreliable. Only comparisons of rings at similar depths are really valid. (Mr. Ashplant here pointed out from diagrams the manner in which distortion was produced.)

Feeling that the measurement of latex tubes in the bark, though possible, would always present so many obstacles as to be too slow for practical utilisation, owing to the distortion effects, he was impelled to try and discover a region of the tree where no secondary growth and no distortion occurred, and where the latex tubes could be studied in their original form. The leaf stalk suggested itself to him as the most likely region, and when the initial difficulties had been overcome, measurement of the latex tubes in the stalk proved quite feasible. Drawings were made to scale of the latex tubes in the leaf stalks of 240 trees which had been under study for years. These drawings, some of which were shown by the speaker, left no doubt as to the existence of significant differences of tube bore, When the final figures for average bore (which in each case represent the average of over 120 measurements) were available, they brought out the fact that these differences were intimately related to yield differences.

No mathematical analyses were necessary for the appreciation of the main facts. One had merely got to set down the tube bore values together with the individual yields.

The correlation tables prepared from the bore values thus measured were exhibited to the meeting by Mr. Ashplant, who drew attention to the very close relation between tube bore and yield. The tables clearly showed latex tube bore to be the chief factor determining yield. The tables did not show, and the speaker did not claim, that the trees with the largest tube bore were necessarily the highest yielders. There was the other important factor of ring number to be taken into account. Given a high number of rings, a tree of just above average tube bore could manifest good yielding capacity, and some of the high-yielders cited were trees of tube bore slightly below the best which had a phenomenally high endowment of latex rings. Mr. Ashplant said that what the table brought out, and what he did claim to have established, was that trees in which the tube bore was below a certain value never developed into good yielders. In the table exhibited nearly 60 per cent. of the trees fell into this class. Conversely, trees with the highest class of tube bore were never poor yielders. Figures were given of the measurements of nearly one hundred of the buddings and high-yielders on the Mundakayam Experimental Station, in confirmation of the latter statement, and it was further mentioned that some buddings grown from imported proven bud wood from Java had all been found to possess latex tubes of large bore.

Two of the tables exhibited are reproduced as plates.

HEREDITARY NATURE OF LATEX TUBE BORE CONFIRMED BY MANURING EXPERIENCE.

Mr. Ashplant briefly referred to the evidence in support if the hereditary character of tube bore already published in the R. G. A. Bulletin. There were, he said, some overlooked but very relevant facts which afforded strong corroborative testimony to the importance and hereditary nature of tube bore. He referred to the experience of manuring in rubber. With rare exceptions, which could all be explained, no noteworthy improve-

ment in the yields of rubber trees had ever been recorded from manuring. It can only be concluded from this that the factor in the tree that chiefly determines latex yields is unaffected by manurial stimulus. Of what nature could this factor be? It could not very well be of a physiological nature, because we know that physiological processes can be considerably heightened by manuring. The production of both leaf and fruit can be markedly increased by manurial applications. Were latex yields determined in a large measure by physiological factors, one might quite reasonably expect yield improvements of 20 to 50 per cent. to follow from manuring.

The non-responsiveness of rubber trees to manures indicated not only that the factor chiefly determinative of latex yield was a structural—that is to say, an anatomical— one but also that it was hereditary. It was part of the foundational framework of the tree.

Now the tube bore factor had been demonstrated by him to be about 75 per cent. responsible for determining yield. Latex tube bore, whether in nursery or mature plants, had been found to be totally unrelated to size of plant. Large bore tubes were just as commonly met with amongst the poorest-grown plants as amongst the well-grown, while in buddings from the same clone of different ages, or growing in soils of varying fertility, no differences in tube bore could be discerned.

Such facts as these provided evidence of the most weighty character in favour of the tube bore theory. The claim that latex tube bore is the hereditary determinant of yield was supported not merely by the close association between this factor and yield; it was supported by the whole body of evidence from every quarter.

We had here an illustration of the manner in which a single important truth brings all sorts of apparently unconnected facts into line. We had at last a satisfactory explanation of the long puzzling failures of manures in rubber. Not the least valuable part of the discovery was the demonstration that the degree of yield improvement possible from manures is rigidly limited. Only by selection could productivity be appreciably and remuneratively raised.

PRACTICABILITY OF TUBE BORE TEST.

After pointing out that the characteristic tube bore could be observed in plants as early as the sixth month, and probably before, Mr. Ashplant dealt with the practicability of a method of selection based on tube bore observations.

One important aspect of selection methods commonly lost sight of was the time factor. To be commercial, a selection test must be capable of being completed in from one to two minutes. At least 200 plants per day must be got through. Although, when he started these investigations, it took him a month to measure the tubes in a single tree, he could now make a rough estimation, good enough for practical purposes, in a few seconds. Experience shows that when properly organised from 200 to 300 plants could be tested per day. The upper and lower classes could be tested in a few seconds. All the trouble was with the middle classes, and here a few mistakes were unavoidable. He estimated that the test could be worked with 80 per cent. efficiency. New plantings selected in this way should have twice the yielding capacity of present areas.

As to the costs of the method of selection proposed, this would be anything from £1 to £5 per acre, according to the kind of staff employed. Even supposing that the cost of planting rubber be raised by £5 per acre, this was a small sum to pay for an enhanced yield of the order 100 per cent. enduring throughout the life of the plantation. Frequently more than £5

was spent on manures which produced, at the most a problematic increase of 10 per cent. and this only for a couple of years.

(At this point Mr. Ashplant exhibited a series of microscopic slides with mounted sections of leaf-stalks. From the images of these thrown upon a screen the differences in the bores of the latex tubes could be easily made out. A set of the original scale drawings of the latex tubes in leaf stalk tangential sections from which the tube diameter measurements utilised in the correlation tables were made was also exhibited to the meeting).

CONCLUDING REMARKS.

You have now had the opportunity of actually seeing for yourselves that recognisable differences in latex tube bore really do exist and cannot be a matter of controversy. In the last few minutes I have shewn you a fact that scientific workers who have been studying rubber trees for the last twenty years have missed. I do not imagine that in the short time at my disposal I have conclusively established to your satisfaction the close connection between tube bore and yield which I claim to have discovered. A little reflection must convince you, however, that these differences in tube bore must necessarily have an important influence on yield.

When I published my first summary of the discovery, it was decried as having been long known. I don't desire to refer again to a recent controversy, but this is an age of publicity, and I ask you gentlemen, whether it is likely that had anyone previously observed these differences and realised their significance they would have kept so entirely dark about it?

Note:—All trees in Table "A" are 9 years old. They vary in girth from 45 c.m. to 100 c.m. Despite this fact and the differences in number of latex rings, the most pronounced correlation of tube bore and yield will be apparent at a glance. This Table also brings out the difficulties of classifying the trees of around average tube bore. It will be noted that in the horizontal classes of from 14 to 15·5 microns, the examples with few rings are poor yielders, while those with many rings are medium to good yielders.

DISCUSSION.

Mr. P. J. Burgess: How do you explain the variation in yield when you come to diseased trees and wound response? When a tree is about to die it yields most vigorously.

Mr. Ashplant: I have frequently found that sick trees have very dilute latex. It appears to be a logical deduction from my theory that by pricking a plant one could determine the yield value by the rate of flow. Taking leaf stalks of equal dimensions, if one severed the leaf stalk the flow ought to give an indication of the yield. I have found that although sometimes the results from pricking are in agreement with the true yield and with the latex tube bore, there is frequently no agreement. The flow from pricking tests, both on leaf stalks and young or old Hevea plants, seems to vary with time of day, and is affected by a number of factors. I could get no uniform results. Fuller study of the question showed that the chief upsetting factor was the very great differences in the density of the latex, which markedly affected the rate and amount of outflow.

Mr. J. G. Wardrop: How do you investigate the plants in the nursery? Is it your proposal that the leaf stalks of these should be subjected to microscopic examination?

Table "A".—Correlation of Average Yield (1927 - 28) and Diameter of Latex Tubes.

(The figures in the body of the Table represent the number of Latex Rings at 3 ft. in each individual tree.)

Average Yield per tapping in C.C. →

Latex tube diameter (in microns) →

	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	96	99	
10·5				17																											1
11·0	18 16	12	10 11	15 11 26	19 11	10																									11
11·5	14	19 10	15	11 14	14				19																						8
12·0	13 25 10	15	11 16	13	12 13	12 19 13	19 17	20 12								33															17
12·5		9 11	11 14 20	14·11 14·11 21·13	14 11 17 13	16 23 16·16 20·10	20 19 16	15 12	20																						27
13·0		12 20 15	15 14	15 17	16·14 15·16	16	19 18 15 26 11	10·18 15 15	18 18 19		25																				25
13·5	13	18 11	13 12 12	12 15 11	14·17 13·15 14 19	13 13 15	14 14 16 16 18	17 12 16 16 14	19 15 16	15	14 19 16	18	16	21																	39
14·0			17	11	13	11·14 13 13	13 15 15 13 13	24·15 10·16	20 20	15 20	16	17 15 20	19	20																	25
14·5				15	20	13	15 16	20	15	18 17 14	17 18	17		16	19 18 18				26 22												19
15·0				11			19 16			14	18	16 17 16	16 19 19 21 19	24 13 13	19			18													18
15·5				17			12 11	13 12	16	15	14	19	21 16		18					25 22		21									15
16·0											14 21 19	16 14		24 14	20 15 16 14 24					27	20	30			23						16
16·5												15				15	18			25											4
17·0												15	13									23	17								4
17·5													17 16																		2
18·0															14													22	17		3
18·5												13									15										2
19·0																		12													1
20·0																								18						23	1
	7	11	14	22	21	19	26	20	12	8	12	14	12	8	11	2	1	2	2	4	2	3	1	1	1			1	1	1	239

Each diameter value in above Table represents the average of over 120 measurements.

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Table "B."—Correlation of Diameter of Latex Tubes and Yield per Ring.

Average Yield per ring per tapping → (Rings in tapping at 3 ft.) Yield per ring 1927-28.

Latex tube diameter (in microns) ↓

	·50	·80	1·10	1·40	1·70	2·00	2·30	2·60	2·90	3·20	3·50	3·80	4·10	4·40	4·70	5·00	5·30	5·60	5·90	6·20	6·50	6·80	7·10	7·40	7·70	8·00	8·30	8·60	8·90	9·20	9·50	9·80	10·10	
10·5				1																														1
11·0	1	1		2	2	2	1		2																									11
11·5			3		1	2		2																										8
12·0	1		3	1	1	2	3	1	3	2																								17
12·5			2	1	2	9	3	3	3	3	1																							27
13·0			1	1	4	2	4	3	3	1	4	1			1																			25
13·5		1	1		2	6	3	6	7	4	5	3	1																					39
14·0				1		1	3	2	6	2	4	4	1		1																			25
14·5					1		3		2	3	1	2	1	1	3	1	1																	19
15·0							1		1	3	1	5		3	2	1		1																18
15·5					1				1		2	3	1	3	3			1																15
16·0										1	1			2	5	2	1	1	1	1	1													16
16·5														1		1	2																	4
17·0																1						2	1											4
17·5															1			1																2
18·0																									2			1						3
18·5																	1															1		2
19·0																									1									1
19·5																																		
20·0																										1							1	2
	2	2	10	7	14	24	21	17	28	19	19	18	4	10	16	6	5	4	1	1	1	2	1		3	1		1				1	1	239

Each diameter value in above Table represents the average of over 120 measurements.

Block by Survey Dept. Ceylon.

Mr. Ashplant: I have written something on this already, and if I have not made myself clear here it was because I did not know how much knowledge to assume. You may remember that I reported that the characteristic differences in tube bore have materialised when the plants were six months old. I did not finish my correlation investigations in time to get on to my nursery young enough, and by the time I tackled the nursery it was already six months of age. I found at that stage exactly the same proportion of the small, medium and large bore plants as I did amongst the ten year old trees. In a number of buddings I have examined I find that characteristic bore differences are already clearly made out when they are only two to three months old. We have recently successfully imported some bud-wood from Java. I have had the opportunity of examining their leaf stalks, and you may be interested to learn that they all have tubes of large bore of my A or B class. My assistant, whom I left to deal with the younger 1928 nurseries, reports that the characteristic tube bore has already materialised and that plants can be successfully examined at three months.

Mr. Eric Macfadyen: You said a native writer could do this work. Would you indicate what the routine would be and what apparatus would be required?

Mr. Ashplant: Some writers whom I have had in training lately were able to cut 40 an hour after four days' practice. I do not think they would have difficulty in cutting 50 to 60. You need one man for cutting sections and another to prepare, stain and mount them. A third man—the best man of all—would make the microscopic observations. I do not know yet whether it would be necessary to have a fourth man, but four would be the maximum. Most of the work except the rather trying actual testing can be done by unskilled men. They must be careful men, of course, who are able to read and write.

Major H. Edgington: Four men for one equipment?

Mr. Ashplant: Yes

Mr. F. D. Ascoli: What is the thickness of a section?

Mr. Ashplant: About 1/32 of an inch.

Mr. C. E. Welldon: Will not soil have an effect on yields?

Mr. Ashplant: There is a certain amount of increase in yield possible from differences in the quality of soils, but the possibilities of variation are very limited for the reason that I pointed out just now. Since tube bore is not influenced by manures and since this is the chief factor determining yield, it is beyond our power to raise trees out of their yield class. The discovery of this new factor and of its unalterable hereditary nature provides us at last with the explanation of the disappointing results from manures.

Mr. C. J. Arnold: Your remarks are in relation to leaf stalk only. Is that so? In that event, from your investigations it will enable us to plant out baskets. The plant will not be in the form of a stump— it will be basket or seedling planting, after investigations in the nursery have been carried out.

Mr. Ashplant: It is much more convenient to have nurseries, and I think ways are known of overcoming the set-back to growth in transplanting that the questioner feels. I am not very much in favour of basket planting for reasons of expense. I am not quite clear as to the first part of your question, but it occurs to me that you might have in your mind that since this work has been done on the leaf stalk, one ought first to establish a relation between the tubes in the stalk and those in the bark.

It is quite immaterial to the theory or practice whether or not there is a correlation between the tubes of the stem and the yield. However, although I have worked out this relation entirely on the leaf stalk, I find there is a most pronounced relation between the tubes of the leaf stalk and those of the stem and between the latter and yield. I have abandoned bark for leaf stalk examinations, because these get rid of the distortions due to the secondary growth and enable the end to be attained more quickly. I should mention that transverse sections are unreliable. All observations should be taken on the tangential plane.

Mr. C. J. Arnold: I am afraid I did not perhaps make myself explicit. What I am driving at is this, if we follow out your research so far as you carry us this afternoon and we employ your methods on the leaf of a plant, I think you said three months old, can I take the leaf stalk or leaf stalks from each individual plant, and shall I be safe in taking my readings of the leaf stalks of my nursery and finding the high yielders and planting out from the basket nursery; shall I be safe to plant out in prepared clearings and be certain that I have high yielders?

Mr. Ashplant: That is my whole point. My discovery amounts to this, that merely by examining and making observations of the tubes in the leaf stalk one can eliminate the C class of tube bore, and in so doing eliminate nearly all those trees that under no circumstances can become good yielders. It is not quite true to say that you will eliminate all of them. It will be advisable to allow for a little subsequent thinning since a percentage of the trees of middling tube bore will not develop sufficient latex rings to be capable of high yield. I have endeavoured to discover whether there are any early indications of a tree's potentialities of ring formation, but I regret to say that I have found no indication. Rings are put on for no rhyme or reason whatever. Sometimes five are put on in a year, sometimes one. I have measured their rate of formation and the distance between each, but unfortunately I have obtained no clue at all. The correlation between the ring number at say two years and the number at maturity is so low as to be quite unusable. Frequently a tree begins badly and picks up in the years following. One's first assessments are often entirely upset. That being so, we have to overcome the difficulty of our ignorance of the ring factor by subsequent thinning out. My proposal would be to plant about 180 selected plants per acre. The thinning out of 50 when about four years old would get rid of everything giving less than six lb. per tree; 30 to 40 trees in excess should be left for a few years to provide for losses from Brown Bast.

Mr. H. L. Coghlan: What would be the effect on budgrafting? Assuming in six months time we can tell, what will be the effect on budgrafting? Shall we continue to budgraft?

Mr. Ashplant: I believe that more recent accounts from Sumatra are very favourable to budgrafting. Theoretically there is everything to be said for budgrafting, but we have discovered a number of snags: weak growth, weak renewal, possibly greater susceptibility to disease, undoubtedly greater susceptibility to Brown Bast. Out of 100 bud mothers, it is doubtful if we should get more 10/15 per cent. of a class suitable for propagation. But I do believe there is a future for budgrafting. Once having proven one's mother trees there is everything to be said for propagating from those. I think the future will prefer a mixture of proven-out buddings and selected seed plants that pass the bore test.

Mr. G. H. Masefield: Perhaps you could tell us whether the whole work might be done by natives. Personally, I cannot see how in practice it will be possible to keep check of 50,000 plants. By what system is it possible to avoid mistakes through mixing the plant numbers? That seems to be one of the big difficulties.

Mr. Ashplant: I think you have hit upon one of the snags not only in this but in all other methods of selection. However, fortunately in the leaf stalk we have an organ which can be removed and labelled with comparative ease. I find that it will be very advisable to have nursery beds of a standard size with, say, 4 rows containing about 100 plants per bed. Supposing the nursery beds are geometrical, that is all the rows are in alignment, it would be almost sufficient to number the rows only. It is quite easy to pencil a number on the plant which will last six months. Immediately a section is cut the number is marked on the slide. We are fortunate in India in being able to get large numbers of men who are good at figures and can read and write English. Properly looked after I do not think there would be much danger of mixing—there is a danger certainly. It has been overcome on my experimental station by organisation, and I think it could be overcome on estates. After all whatever selection method we ultimately find best, we shall still be up against the difficulty mentioned, and if the European staffs and the native staffs of rubber estates are incapable of marking plants in a nursery and keeping records of those plants until the final stage of selection, it is surely an admission of incompetence. Labelling and checking of this character is only routine work. It is quite simple work, quite within the capacity of a man with a systematic mind.

Mr. G. H. Masefield: I have very great pleasure in proposing a hearty vote of thanks to Mr. Ashplant for his most interesting lecture. I had the privilege early this year of paying a visit to Mr. Ashplant at Mundakayam and I must say I was greatly impressed with the tremendous amount of work he has put into this subject, working out the relationship between bore and yield. If anybody could see the charts as I have done myself I think you would realise how much we owe to Mr. Ashplant for the work he has done in Southern India. Already by his solution of the secondary leaf fall problem, I think he can say he has saved the Rubber Industry in Southern India. Gentlemen, I ask you to pass this vote of thanks with acclamation.

NOTE ON MR. ASHPLANT'S WORK ON LATEX TUBE BORE.

The use of budded rubber and of selected seed both have for their objective the production of a stand of rubber of uniformly high-yielding powers. The main obstacle in the path of workers has been the time factor. The testing of mother trees for budding purposes is a lengthy process and, unfortunately, high-yielding mother trees have not always given progeny with high-yielding characters. It has therefore been necessary to prove mother trees, so involving a further expenditure of time. Similar difficulties have occurred in the selection of seed. Rubber is normally cross-fertilised, and in consequence all the known high yielders are of mixed parentage and their progeny will be of a mixed nature. Rigid selection from selected clones in isolated seed gardens may result in the production of seed which is approximately pure as regards yield characters. Here again the time factor occurs and twenty five years is a conservative estimate of the time necessary to achieve this most desirable object, although, in successive generations, the seed obtained would probably be better than that from an average source.

Any suggestion, therefore, that promises to eliminate the time factor in selection of high-yielding trees is of importance and must be investigated fully. Mr. Ashplant, in the preceding article, has indicated a method by

which he claims to be able to select plants in the nursery and to ensure (with 80% efficiency) at least the elimination of unprofitable trees.

Mr. Ashplant points out that attempts to correlate yield with the number of latex rows in the cortex have given results of low significance. He states that this is due to the variation in diameter of latex vessels in individual trees. He also points out that a fair measurement of latex tube bore cannot be obtained from sections of the cortex of the stem owing to distortions caused by secondary growth. He has therefore used the leaf-stalk or petiole for his determinations, and has come to conclusions which, if substantiated by full figures, are of considerable importance. He states that tube bore is an hereditary and constant character and gives a frequency array showing the relationship between latex tube bore and yield of 239 nine-year old trees. The correlation co-efficient of this array has been determined and is + ·75 which indicates that there is a very significant relationship between the diameter of latex vessels and the yield. In other words the greater the bore, the greater the yield.

It is unfortunate that Mr. Ashplant has not published a detailed account of his experiments and it is to be hoped that he will do so as soon as possible. He has not told us the variation in latex tube diameters encountered in one petiole nor the variation in latex tube diameters of a number of petioles from one tree. Some errors have crept into his frequency arrays, possibly in reproduction. It is to be assumed that Mr. Ashplant has evidence for his statements, but, until full data are published and contributory experiments have been carried out elsewhere, confirmation of his theory must be withheld, particularly in view of the criticism put forward by Malayan workers.

If Mr. Ashplant's work is confirmed, it will be a relatively simple matter to obtain areas of rubber containing only a low percentage of poor yielders. Selection by examination of petioles in the nursery will ensure that no trees but those with wide latex vessels are planted. Subsequent testing of the yields and judicious thinning out will tend to produce a uniform stand of good yielders. It is not to be expected that areas planted in this way will prove equal in yielding capacity to those planted either with buddings from proved mother trees or with pure seed from high-yielding parents Since, however, neither budding nor seed selection has yet reached a stag when results can be guaranteed, it would appear that, subject to confirmation, Mr. Ashplant's method is likely to prove of great immediate value to the rubber planting community.—M. P.

MANURING OF RUBBER.

1.—GENERAL ASPECTS OF THE PROBLEM.*

[Note.—It is of interest to recall the fact that manurial experiments with rubber in Ceylon which were regarded as more or less inconclusive in their results have been shown by further examination (vide this journal for November 1928, pages 263-271) to provide strong presumptive evidence that nitrogen gave significant increases of yield. It will be seen from the paper by the Economic Botanist in the present number of *The Tropical Agriculturist* that further examination of the same figures has confirmed the usefulness of nitrogen. Manurial experiments are being conducted by the Rubber Research Scheme at Arapolakande and an experiment designed on lines of modern field experimentation will be begun at Peradeniya in 1930.—*Ed. T. A.*]

RECENT years have seen a very marked growth of interest in the possibilities of applying artificial fertilisers to rubber. The turning of attention in this direction is the inevitable outcome of the increasing age of estates, revealing ever more clearly those planting sites which have unsatisfactory features, but it is possible that the main impetus to interest has been the reports of remarkable results from manuring in particular cases. That these are rather exceptional has already been shown by more disappointing results in many other cases, but the balance of opinion among those of experience seems to be rather in favour of manuring than against it. Only a small proportion of the trials made have been conducted on a satisfactory comparative basis and, until this is done, the belief in the efficacy of manuring cannot rest on a scientific basis. This state of the subject leaves a good deal of confusion due to basing arguments upon experience with other crops, so that it is necessary to point out at the outset the sharp contrasts which exist between the case of rubber and that of the other crops for which experience of manuring is extensive and exact.

Comparing the cycle of plant nutrition and growth of an ordinary arable crop and that of a rubber estate it becomes at once evident that the differences are fundamental. In the first case the growth cycle is usually completed within the year, and a very large proportion of the total growth made is removed entirely from the farm. Hence there is a continual extraction and removal of plant nutrients from the soil, and an inevitable tendency towards soil exhaustion. This is offset by the yearly opportunity when the land is clear to effect amelioration by means of cultivation and manuring. In the case of rubber the plant growth is a slow cumulative one with such a small amount of plant nutrients removed in the latex crop as to be almost negligible. Under proper conditions the leaf-fall goes back into the soil, so that the cycle of changes takes place without any great loss. By neglect of conservation the losses on rubber estates have, of course, often

* By Dr. W. B. Haines in *The Quarterly Journal of the Rubber Research Institute of Malaya*, Vol. 1, Nos. 1 and 2, January, 1929.

been serious, but it is apparent that there is no such inevitability about the approach to soil exhaustion as there is in the case of arable cultivation. This would lead one to expect that the application of manuring practice to rubber would have a more limited scope.

Another consideration which would tend to instil a cautious approach to the subject is the much less direct connection which exists between nutrition and yield. The aim usually pursued in manuring is a heavier production of fruit or of vegetative growth and more is understood regarding these than regarding the responses involved in increased latex secretion. By far the largest differences to be observed in yield are to be attributed to innerent character. Hence the most promising methods for increasing the acreage yield are those which will provide trees of high yielding character. The fulfilment of such methods, however, must take much time, so that manuring must be examined in all its possibilities as a method of improving the existing stands of rubber. While general improvement can usually be effected (as regards appearence of foliage for example) we as yet know little regarding specific effects upon latex production. With the advancement of knowledge, however, the possibility is not to be overlooked that a connection will be found between some phase of nutrition and the quantity of latex produced. At present nitrogenous manuring (as being productive generally of sappy vegetative growth), is the most promising, but evidence is not wanting of more specific effects upon latex production of the kind indicated.

There is a third consideration which must qualify the expectation of great improvements from manuring in some cases. In cases where the site has always been poor and the trees have been stunted for many years it may well be asked whether a sufficiently favourable response to manuring may be looked for. There must always be some hope for a tree not actually diseased, but successful manuring must look for vigor in the tree and satisfactory conditions as regards moisture supply and similar matters. Too often a piece of rubber has been selected for a manuring trial on the assumption that the worse the rubber the more the room for improvement. To select the best opportunity for improvement would often lead to more encouraging results. Even on comparatively good sites the fertility of the soil may lag far behind the other abundant conditions of light, heat and moisture. In such a case manuring improves the one limiting factor and produces a benefit, while in more adverse cases other limiting factors may be present to prevent any response. The above considerations are applied to the general prospect of increasing estate yields by extensive use of fertilisers. The value of manures for special purposes should need no emphasising. Much may be done towards the improvement of nurseries and the establishment of cover crops by judicious use of fertilisers on the lines of well-established practice. By applications made at the time of planting out rubber a healthy and uniform growth can often be ensured and the young trees pulled through their more critical early stages when adverse conditions of weather may catch them at a disadvantage. The cost of manuring in such a case is very small since only the planting holes need to be treated.

The economic valuation of results from manuring rubber will present considerable difficulties. Apart from those attending the fluctuating market values of rubber it will take long periods to assess properly the full effect of a single application of manures, whether as regards increased yields or increased capital value in growth of the trees and in bark renewal. Experiments with annual crops give their end and result within the season, but effects on rubber are likely to take many such cycles to work themselves out. Further, there is the probable lengthening of the economic life of the trees to be taken into account. Until we are in a position to estimate the benefit on all these points the economics of the problem must remain somewhat indefinite. In some cases the immediate return from manuring has repaid the cost, but it is obviously inadequate to pass judgment on the basis of returns over a short time.

The long periods during which experiments must run call special attention to the necessity of laying them down with great care and foresight. In recent years the subject of field experimentation has been much developed and the guiding principles laid down. The potential value of the results from test plots may often be increased many times by changes in the layout which involve no extra expense and very little extra demands upon time and trouble. The questions involved will form the subject of the next article. Since all types of soil and situation need to be covered in order to provide full data, the desired end can only be attained by experiments scattered over many estates, and all those who have rubber likely to be benefited by manuring should be encouraged to make trials. The management is then sure of getting such results as are applicable to the particular conditions of the estate, while at the same time contributing to the common stock of knowledge.

BUNCHY TOP DISEASE OF BANANAS IN QUEENSLAND.*

BUNCHY top is by far the most serious disease affecting the prosperity of the banana-grower in Queensland. In northern New South Wales and the extreme southern portion of coastal Queensland the once thriving banana-growing industry has, for the time being, been practically wiped out by the ravages of this malady. A similar fate awaits those districts so far free or only lightly affected unless the recommendations designed for the exclusion and control of the disease are strictly adhered to.

The first definite recognition of the presence in Australia of the disease now known as bunchy top occurred in 1913. Apparently it was introduced by means of infected suckers imported from Fiji, where the disease had been prevalent for many years. In 1922 the trouble began to assume such serious proportions as to call for special investigation by the officers of the two States concerned. Finally, in 1924, on the recommendation of a Board representing the Commonwealth Institute of Science and Industry and the Agricultural Departments of New South Wales and Queensland, the Bunchy Top Investigation Committee was appointed consisting of Professor E. J. Goddard (Supervisor), Mr. C. P. J. Magee (Assistant Plant Pathologist), and Mr. H. Collard (Horticulturist). The expenses entailed were met co-operatively by the Commonwealth and the Departments of the States concerned. In Bulletin No. 30 of the Council for Scientific and Industrial Research, Mr. Magee has detailed the result of the investigation, and the nature of the disease and its means of transmission are shown to have been clearly demonstrated, with the result that sound control measures may now be advocated.

SYMPTOMS.

The appearance of a typical bunchy top plant showing the later stages of the disease in such as connot readily be confused with any other banana malady. However, for the purposes of prosecuting efficient control measures it is necessary to be able to detect the first visible symptoms of the disease. These can be searchd for by holding the lower part of the youngest leaf of the plant so as to look at it from the back with the light shining through. If the plant has become infected there will be noticed short broken lines of a dark-green colour lying between and parallel to the clear veins which run out at right angles to the midrib. The dark streaks are broken up into short irregular lengths so as to resemble the signs of the Morse code. At first the dots and dashes may be somewhat sparsely scattered, but in the later stages of attack these may be so numerous as to form almost continuous dark-green lines, which give to the affected leaf a somewhat darker green appearance than normal. All the leaves subsequently formed exhibit evidence of the disease and to an increasing extent.

The following additional symptoms usually only appear three weeks or more after the marking just described first becomes visible. Suckers infected from the parent, however, may exhibit them from the start and to even greater intensity. Instead of waiting until it is properly free from

* By J. H. Simmonds, M. Sc., in the *Queensland Agricultural Journal*, Vol. 30, part 5, November, 1928.

the pseudo-stem the newly-thrown leaf will commence unfolding from the top in a funnel-shaped manner. The leaves become reduced in length and width until they are of a somewhat elliptical shape. The blade shows a tendency to droop along the midrib so that the backs of each side approach one another. The edges are rather more wavy than usual and are sometimes slightly curled inwards. Affected leaves exhibit a marked brittleness not natural to the healthy plant. Instead of increasing in size in their order of growth the leaves of a bunchy top plant gradually become smaller. The leaf stalk also fails to elongate and bears the leaf in a more erect manner. The result is the formation of a crown of stiff, narrow, erectly-growing leaves bunched together in a typically rosetted manner. A bunchy top plant affected in its early stages of growth rarely throws a bunch, and when, owing to a late infection, this does appear it is commonly stunted and possibly malformed owing to the constricted state of the top of the pseudo-stem through which it has to pass.

CAUSE.

It has now been demonstrated conclusively that bunchy top belongs to that type of plant malady known as a virus disease. The various plant diseases included in this type show many general points of similarity, of which the chief lies in the fact that the causal agents are of such minute size that they have so far defied all attempts to view them microscopically. What little is known regarding the nature of the infectious agent or virus concerned in the different virus diseases has been determined by experimenting with the plant juice in which it is known to be present. A virus disease may be transmitted from one plant to another in various ways. For some it is merely necessary to inoculate a healthy plant with the expressed juice from a diseased individual. In other cases grafting of diseased on to healthy tissue becomes necessary. In the more specialised forms the virus is conveyed from plant to plant by means of an insect vector. Bunchy top belongs to the latter type.

This disease is disseminated by means of the dark banana aphis (*Pentalonia nigronervosa*) which, in pursuance of its normal feeding habits, may first suck the juice of a diseased plant and then migrate and carry out the same process on a healthy one with the result that the latter becomes inoculated with the virus and so contracts the disease. This insect is responsible for the spread of bunchy top throughout a plantation and between neighbouring plantations. When one plant contracts the disease the other members of the stool usually become infected as a result of the virus making its way through the connections which link up the various individual corms. Suckers arising from an affected plant almost invariably exhibit symptoms of primary infection from the parent.

CONTROL.

When considering methods for the control of bunchy top it is necessary to stress the following points:—

(1) Bunchy top is a disease of a systemic nature. The causal virus being present within the living tissue of the host cannot be destroyed by any chemical or mechanical treatment known at the present time, other than by destruction of the plant itself. In other words, a plant cannot be cured once it has contracted the disease.

(2) Bunchy top may be introduced into a clean area by means of suckers infected with the virus which have been taken from a diseased plantation, and also, if centres of infection are not too far distant, by the possible influx of infected aphis.

(3) The disease is spread within an affected area and also the limits of that area gradually extended by (a) the planting of infected suckers, (b) the transmission of the virus from diseased to healthy plants by the banana aphis.

(4) An attempt to eliminate bunchy top by complete control of the aphis is beset by so many practical difficulties in the average banana plantation that the method cannot be entertained.

Therefore, since it has not been found possible to either cure a diseased plant or eliminate the means of transmission of the virus, it is necessary to concentrate on a programme of *eradication* whereby all sources of the infectious agent are completely eliminated by destruction of all diseased plants. With this object in view proclamations have been made which prohibit (1) the transfer of any suckers whatsoever from infected districts into those areas still free from the disease, (2) the removal of suckers from any plantation within an affected area unless the plantation in question has been inspected and found free from the disease.

If this proclamation is adhered to conscientiously by all banana-growers —the very existence of the banana industry in Queensland depends on this—then the following objects will be obtained. (1) Clean isolated areas will tend to remain clean; (2) spread within affected areas will be greatly reduced.

Growers must not think that these regulations alone are going to eliminate bunchy top. It should hardly be necessary to stress the point that, owing to the rapidity with which bunchy top may spread, all growers within an affected area must consider their position as serious. If they do not wish their plantations to follow the fate of those in the Tweed area the following recommendations must be adhered to. (1) Set aside a definite time in every week in which to carry out inspection of the plantation for signs of bunchy top invasion. Each plant should be separately examined and special attention should be paid to the youngest leaf on each plant in order that the earliest signs of infection may be detected. The area of the plantation should be reduced if necessary to a size which will enable careful examination of this nature to be carried out. Special care should be taken during the warmer months when the aphis are most numerous and active. (2) If any plant should be found to be infected, the whole stool must be dealt with as follows. First spray the stool thoroughly with Black Leaf 40 to kill all aphis present. Particular attention should be paid to the crevices round leaf bases, &c. Black Leaf 40 should be used at the rate of a dessert-spoonful to a gallon of water, to which soft soap has previously been added until a good lather is obtained. After spraying, dig out the whole stool and cut the plant up into small pieces which will quickly dry out. It must always be borne in mind that it is not sufficient to treat only the individual plant affected, as the virus may have already passed to other members of the stool, although its presence there is not yet apparent. (3) All growers should co-operate in seeing that all diseased plants are eradicated from their districts, as it is only by achieveing this object that the industry can be expected to again reach a stable basis in the affected areas.

[Work on bunchy top disease in Ceylon has indicated that the problem may not be so simple in this country. Attention has been drawn in *The Tropical Agriculturist* (Vol. LXXI. p. 141, September 1928) to the fact that root disease may have some bearing on the etiology of bunchy top in Ceylon, and a series of experiments is being carried out by the Government Entomologist to determine if the virus transmitted by the aphis, *Pentalonia nigronervosa* Coq., is a factor in the incidence of the disease. *Ed. T. A.*]

APPLICATION OF SCIENCE IN AGRICULTURE.*

IT is widely recognised that science finds useful application in agriculture; indeed, the degree of recognition is so great as to be sometimes almost embarrassing. At the present time there is a tendency to look to science as the best, if not the only, means to find a way out of the difficult situation in which agriculturists in all countries find themselves: not uncommonly the man of science is called in—late in the day, perhaps—to retrieve the errors and perchance to share the blame of mistakes by politicians, business men, and so-called practical experts, who have embarked on some enterprise and got themselves into a situation out of which extrication is difficult. All this is a new development: it is in striking contrast to the position of thirty years ago, when the scientific worker in agriculture was at best only tolerated and rarely taken seriously. The British Government would have nothing to do with him; no grants were available—indeed, a distinguished Civil Servant, in response to a request for a research grant, declared that he could not conceive of circumstances in which any Government would be interested in scientific research for agriculture. It is a great change, and it has proceeded rapidly, mostly since the War, though it was not started by the War, but had, in fact, set in before that, and indeed was well on its way in 1914.

The actual progress of events, so far as Great Britain is concerned, is well known. In 1890 the Government of the day, having raised money by taxing whisky, spent it on Technical Education including Agricultural Education: in consequence Agricultural Colleges and Departments of Universities were started and serious efforts made to educate young people for agricultural life: some bolder spirits even tried to educate farmers. The more progressive of the teachers soon discovered the need for learning something of the subject themselves, and they proceeded to make experiments with the purpose of gaining knowledge. These men prospered as they deserved. Farmers caught the spirit, and experimental farms and plots sprang up all round the countryside. Much information of great value to the grower was obtained, and its value was widely recognised. The Government made a sharp distinction between education and research, however, and while they would make grants for educational purposes, they made none for research. The distinction always puzzled the layman, and it was abolished in 1909-10, when Mr. Lloyd George secured the Act setting up the Development Fund, out of which increasing amounts have been voted for research each year. So profoundly has research impressed the farmers that when the £1,000,000 was alloted to agriculture in compensation for the repeal of the Corn Production Act, the farmers themselves asked that it should be used for "research and education," because, as the President of the National Farmers' Union truly said, "Without research there can be no agricultural education."

Now this position could not have been reached without very substantial reasons. English farmers are the last people to be dazzled by the glamour of pure scholarship or University prestige; they have no innate veneration for the professor as such. The fact that agricultural science has attained so high a position is substantial proof that it deserved success.

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* By Sir John Russell, F.R.S., in *The Empire Cotton Growing Review*, Vol. VI, No. 1, January, 1929.

If one looks over the records of agricultural improvement for the past eight years, it is easy to see why this position has been attained.

The first great triumph of science was in 1840, when fifty years of work by chemists and botanists had revealed the essential facts of plant nutrition, and Liebig, Lawes, and Gilbert put this discovery to practical use by the introduction of artificial fertilisers. The great improvement of crop yield, and, perhaps more important, the increased certainty of yield in bad seasons, dispelled the old fear of catastrophe and famine, and raised farm production to new levels. Some forty years later a new triumph was to come, for the terrible potato blight which had devastated Ireland and inflicted untold misery upon thousands of her peasants was finally brought under control, and has never since been a serious menace. This has been followed by the gradual control of many of the insect and fungus pests that had done so much damage on the farm.

Some twenty years later came the third triumph, when Bateson, studying the laws of heredity, rediscovered the work of Mendel, which had lain buried for over forty years, and attracted a group of enthusiastic workers to plant genetics, which has since greatly added to the resources of the farmer by providing him with new varieties of crops, but still more by providing the plant breeder with a set of principles that enable him within limits to build up new varieties almost to specification. Finally, there comes the latest achievement of fixing gaseous nitrogen from the air and converting it into fertilisers, thus securing indefinitely large amounts of those most important substances for the future.

Perhaps the simplest way of summing up the achievements of science in agriculture is to compare the prediction of Sir William Crookes in 1898 with the accomplishments of agriculture today. Speaking with a full knowledge of science as it was then, he predicted that the world in 1931 would require 90 million tons of wheat to feed its population, but that, *unless science discovered new methods,* this represented the utmost that the wheat growers of the world could do; afterwards the world would be faced with starvation. The accuracy of his forecast in regard to consumption shows how carefully he had made his calculation: the world does, as he predicted, require in 1928 about 90 to 100 million tons of wheat. But science has advanced so much as to upset altogether his calculations about the possible production. The 90 millions which he thought was the limit without new methods had been much exceeded even in 1911, and could be considerably exceeded today if it were needed. The fear of world starvation has gone, the achievements of science are only at their beginning, and there remains ample scope for patrons of science and for the patient efforts of the quiet scientific worker.

In spite of these brilliant successes agriculture is not prosperous, and, as Mr. Hewison points out, it suffers even in those countries where science is most diligently applied to it. It would, however, be fallacious to attribute the suffering in agriculture directly to the progress of science. The application of science to agriculture is not an isolated phenomenon: science is being applied also to industry, and whenever this happens production increases. Industries like the motor industry that have developed seductive selling agencies and played on the idea of "obsolescence" so successfully that the possessor of a perfectly good car feels bound to scrap it because a newer model has come out—these industries have remained prosperous. So also, but to a less extent, have those branches of agriculture that have followed the same methods: setting up good selling agencies and presenting goods in an attractive form to wheedle money out of a hesitating purchaser—such as some of the branches of market gardening, fruit and dairy production. But where salesmanship is less effective the industry has languished: science has shown the way to greater production, but there has been no corresponding

growth in demand: men have been thrown out of work and producers have been unable to sell their goods. It is difficult to see the remedy; there is always a tail-end in every body of men, whether workers or producers, and every advancement of science makes it less necessary to employ these people, so that they tend to be left unneeded. It is part of the cost of the inevitable forward march of science, and although some solution may some day be found, none is yet in sight.

Science, therefore, cannot cure all ills of agriculture or of modern civilization, particularly those arising out of its very success in increasing production per acre and per man, and in dispensing with the less efficient worker and producer: indeed, as science advances, the efficiency line will be drawn higher and higher, and an increasing proportion of people will fall below it, unwanted and unemployable. What is to become of them is a social problem outside the scope of this paper.

So far as cotton is concerned, science can unquestionably increase the output per acre and per man, and also reduce the wastes and losses of the growing crop from diseases and pests: it can thus enable the crop to be sold more cheaply, or in the alternative it can give the grower a larger return. Within limits it can develop new cottons, combining the desirable features of older sorts. These objects are still important, and so long as they remain so there will be need for scientific work.

This work is of two kinds, roughly classified in simple language as gaining information, and using it: in official language as fundamental or pure science, and applied science, but the distinction is not sharp. The chemical and botanical work that revealed the food of plants was pure science—the gaining of information: the experiments made with the foods which when manufactured were called artificial fertilisers, are applied science—the using of the information. Without the pure science there would be no applied science. Until the information is obtained it cannot be used. If we are to make further advances corresponding with the great ones already described, it will only be after more advances in pure science.

Although the distinction between pure and applied science is not sharp so far as the subject-matter is concerned, there are clear-cut distinctions in practice. Pure science is concerned with general principles: applied science with solutions of particular problems. Pure science must be as exact as possible: applied science is satisfied if the figure is "near enough" or the method "generally works." From the practical point of view the most important difference is that pure science can be studied anywhere, while the application must usually be made on the spot. This is important for two reasons: modern scientific work is very costly, requiring elaborate apparatus, a multiplicity of books and journals, and, most important of all, ready access to other scientific workers with whom the investigator may discuss his problems from day to day, and gain useful help and constructive criticism. An isolated research institute, however large and varied its staff, and however rich its library and equipments, is never large enough, and the workers always need access to larger libraries, meetings of scientific societies, demonstrations and exhibits of scientific apparatus or methods, and lectures by men of the highest rank in their respective subjects. These requirements make it easier to do fundamental work at home than in most parts of the Empire, for wherever in England the research worker happens to be, he usually has two or three Universities within 50 or 100 miles, and he can always attend lectures, meet fellow-workers, obtain books from libraries, or see and try new forms of apparatus at very little expenditure of time. This is not the only advantage of doing the fundamental work at home: Mr. Hewison has pointed out the great difference in length of working life of a man in the tropics and at

home: indeed, he suggests—and in view of his experience no one will lightly quarrel with him—that the man at home should achieve at least four times as much as the man in the tropics.

In research work, however, the obviously advantageous course is not necessarily the best, for the research worker is apt to be an elusive person conforming to no rules whatsoever: and, in point of fact, some very good fundamental work has been and no doubt will continue to be done in tropical conditions where everything seemed unfavourable. For purposes of organisation, however, it remains generally true that the home institution has the advantage when it comes to fundamental work.

In practice it is rarely possible to dissociate the pure from the applied science, there being, as already pointed out, no logical distinction between them. For many, if not most, of the problems by which the field expert is troubled, the underlying principles are not properly known, and until they are the problem cannot be solved: a rough working solution may be found, but it will always be liable to break down. The logical course would be for the field expert himself to tackle the matter fully, but as he has probably already got far more work than he can manage, he finds this impossible. It would be a great advantage if he could farm out the fundamental part of the investigation and himself do only what must be done on the spot, and yet remain in close touch with the fundamental investigator, so as to utilise fully all the information obtained.

The simplest way of discovering how far this kind of collaboration is possible is to try the experiment and see how it works. We are making the attempt at Rothamsted, but as we cannot afford wasted efforts, the work is being so arranged that it must still give valuable fundamental information, even if it does not link up as easily as we hope with the requirements of the man in the field.

Three attempts are being made. Agricultural investigators are well aware that field experiments, simple as they appear to non-experts, rarely give clear-cut results. So long as only single plots are used a result may seem to emerge, but the figures are apt to be very confusing if the plots are duplicated or, better still, replicated several times. We periodically receive at Rothamsted a pile of data obtained in field experiments, obviously made with care, which seem to be wholly unintelligible. The trouble arises from several causes: from irregularities in the seed, the soil and watering, the cultivation, and the incidence of diseases and pests. Of these, irregularities in the seed can often be minimised by the use of a pure-line; cultivation of experimental plots may be made more uniform than over whole fields, while the incidence of disease, if it cannot be regulated, can at least be recorded. There remain the irregularities of soil and water distribution, which may escape not only control but even recognition. These have recently been studied at Rothamsted by the Statistical Department, and methods have been devised for casting out their effects. The methods are not easily reduced to rule, and in the hands of in-expert people may prove treacherous, but they can easily be applied by any mathemetically trained person who knows something of statistical theory.

Fortunately this kind of work need not be done on the spot. If the worker can state in writing what field experiment he wishes to make, and can attach thereto some of the records of previous field experiments showing the kind of results usually obtained, the Rothamsted Statistical Department can draw up specimen plans of the field experiment from which the agriculturist can select the one best suited for field operations. Then when the results are to hand, the Rothamsted Department can inform the experimenter

of their probable value and of the deductions that can safely be drawn from them, as well as the indications or suggestions not fully significant but yet deserving of further examination.

This kind of service can already be rendered by the home institute to the tropical worker, and it has the advantage of securing the maximum value from the field experiments in the minimum of time without the necessity for setting up a costly statistical department on the spot, which would be justified only if there were sufficient work for a trained man, aided by skilled computers and efficient calculating machines.

A more difficult group of subjects is also being studied in the Physical and Chemical Departments at Rothamsted with considerable promise of a successful issue. It is well known that irrigation may cause considerable soil deterioration, and that schemes attractive from the political and engineering points of view may, after a time, break down in practice. The soil chemistry of the older textbooks had no explanation to offer; certain new conceptions of the nature of clay are, however, proving much more helpful. In a normal fertile soil the clay is a complex compound of which the basic part is mainly calcium, and the acid part is an alumino-silicic acid: clay can indeed be likened to a calcium salt. Under irrigation conditions the calcium may be displaced by sodium, giving a sodium clay altogether different from the calcium clay, not suited to the same crops nor amenable to the same or, indeed, any known treatment. The conditions determining the formation of the sodium clay, its properties, and its reaction to water and to salts, are being studied in the laboratory, in order to give full information to the man who is trying to solve the field problem. Further difficulties arise from the salts usually present in any dry area where irrigation is desirable: they act on the plant both directly and indirectly through their effects on the soil, influencing its growth, its reaction to parasitic organisms or diseases, and to seasonal factors. These problems can be disentangled from the local field problem and studied separately: the information when passed back to the field worker cannot fail to help him in finding some way round his difficulties.

The third direction in which attempts are being made to help the tropical worker is in the study of plant diseases. Of these there can be no end, because new crops and new conditions may change a hitherto blameless organism into a serious pest, and once a disease begins it sooner or later spreads widely, thanks to our efficient modern transport. The Imperial Bureaus of Mycology and of Entomology have already rendered valuable service in the spreading of the news, telling the field experts what to look out for, locating the present situation of the disease, and reporting on control measures so far tried. They also examine and identify fungi and insects sent in to them. They do not, however, themselves conduct researches into the relationship of the parasite and the host plant, though the Bureau of Entomology has a laboratory for the breeding of parasites of insect pests.

Two attempts are now being made at Rothamsted to go further than this. Mr. R. H. Stoughton is working in conjunction with Major Archibald and Mr. R. E. Massey in the Sudan on the angular leaf-spot type of the Black Arm Disease of cotton caused by *Bacterium malvacearum*. Mr. Stoughton has set up miniature glass houses in which cotton is growing under any desired conditions of temperature, humidity, and light. Everything is controlled electrically: a slight rise in temperature or humidity at once sets the correcting mechanisms going to put things right once more: the electric sun is made to rise at six and set at six automatically. Clean, strong cotton plants are grown right through to seed formation: indeed, seed free from any taint of disease has been raised here and sent out to the Sudan. Some of the plants are deliberately infected with the disease-producing organism, and its development in the tissue is studied; the relationships of soil and air tempera-

true, water supply in the soil, humidity of the atmosphere, and other factors to its progress are fully investigated. The information thus obtained will, of course, be checked in the Sudan, but already it appears likely to save a lot of work there by discriminating between the paths which will probably lead somewhere, and those that will not. As all investigators know, much of the time spent in applied research is taken up in following the wrong tract, and it is exceedingly helpful to be put on the probably right one straight away. Naturally the work has to be done cautiously, but Mr. Stoughton has had considerable tropical experience and is in frequent communication with the Sudan workers.

The other investigation to be made is into the nature of the virus diseases of plants: this is being done by Dr. Henderson Smith, who will be assisted by a cytologist, a plant physiologist, and an entomologist. These diseases are very serious already: they are spreading throughout the Empire, and the agent that causes them has not yet been discovered, so that they cannot be dealt with. If the agent is an organism it is so small that it passes through filters, and it cannot be grown on any medium yet tried. Two diseases can combine to produce a third different from either. Dr. Henderson Smith will first try to analyse the diseases and to obtain all the information possible about the virus causing each. This work could hardly be done in the tropics: it will be costly and slow enough in England with men working all their time under favourable conditions, and with abundant equipment.

Up to the present our experience leads me to be hopeful about the future. With the speeding-up of communications between all parts of the Empire and England there is rising a spirit of co-operation between agricultural workers overseas and those at home: this has been fostered by the grants made by the Empire Cotton Growing Corporation to certain home institutions, Rothamsted among others, thereby securing centres where experts in cotton-growing can be sure of a welcome and a sympathetic dicusssion of their problems. Further, the development of scientific appliances enables the investigator to reproduce conditions of growth with an accuracy and certainty unattainable twenty years ago. The home institution can therefore go much further than has hitherto been possible towards lightening the task of the man in the field by providing him with precise information obtained under temperature and moisture conditions identical with his own. It is impossible to say how far this co-operation may lead: for the present we cordially invite the field experts to visit Rothamsted whenever they are home, and to see how far any information obtained or obtainable here is likely to help them.

HORTICULTURE IN THE TROPICS.*

CEYLON is noted for its tropical luxuriance, and one gets the first impressions of this in its capital of Colombo with its masses of green foliage and the variegated colours of numbers of flowering plants to be seen everywhere.

The Victoria Park is well worth a visit for the many interesting plants which it contains, among them, large Cinnamon trees, a giant *Eucalyptus albus* with conspicuous white bark, the endemic *Sterculia Thwaitesii* with large buttress stems, *Casuarina equisetifolia* 70 feet or more high with switchlike branches, and, hanging like a huge curtain from the branches of the Wild Olive, the largest plant of *Vanula planifolia* I saw during my travels. Clothing the stems of *Terminalia glabra* was the epiphytic *Scindapsus aureus,* reaching 30 feet in height, and a lovely plant it is seen in this way. Climbers such as Bignonias, Allamandas, Bougainvillaeas, and the beautiful *Antigonon leptopus* in its pink and white forms are used here, as elsewhere in Colombo, for their rich colour effects which in the tropical sunshine are very brilliant.

In many of the charming bungalow gardens about Colombo, *Spathoglottis (aurea)* and *S. plicata* are used for bedding much as we use Pelargoniums at home, and they give royal feasts of colour, as do *Vinca rosea* and its variety *alba.*

Owing to its different elevations Ceylon has varying temperatures and climate which make it possible to grow a wide range of crops. At Colombo the mean temperature for January is 79°, and for April 82½°, while at Nuwara Eliya at 6,188 feet elevation, where the thermometer sometimes falls below freezing point, the average temperature is 58°. In the large planting districts, Dimbula, Dikoya, Maskeliya, and Uva the average is 65° all the year round.

The rainfall varies from 37 inches at Hambantota to over 200 inches on the Adam's Peak range, while in Colombo it is 88 inches.

Ceylon has an area available for cultivation (excluding lakes and backwaters) of some 12,000,000 acres, and at the present time about 4 millions are under cultivation or used for pasturage, the areas devoted to the chief crops being, in acres : rice 610,000, other food grasses 120,000, coconuts 750,000, areca, palmyra and kitul palms 140,000, tea 398,00, rubber 184,000, cinnamon 45,000, cardamoms 9,000, other spices 10,000, sugar 20,000, cacao 36,000, fruit-bearing trees 250,000, tobacco 25,000, essential oils 40,000, other cultivated grasses 15,000, vegetable and garden produce 350,000, natural pasturage 1,000,000 (about).

From Colombo a visit was made to Mount Lavinia, formerly the residence of the Governor, but now a health resort, surrounded by coconut groves. Several pretty Sinhalese villages are passed on the way, and one may gain some idea of the beauty of the country and its dignified inhabitants.

From Colombo I went to Kandy, the mountain capital of Ceylon, from which the famous gardens of Peradeniya are four miles distant. By train the journey takes four hours and is most attractive owing to the constant change of scene from the low country to the mountain zone of the Central Province. For some distance the train runs through flat rice fields, which

* Part of a paper by W. Hales, A.L.S., in *The Journal of the Royal Horticultural Society,* Vol. 53, part 2, July 1928.

alternate with gentle knolls on which stand the residences of the native cultivators surrounded by groves of plantains, jak fruits, bending coconut palms contrasting gracefully with the straight and slim arecanut and the elegant sugar palm, while here and there an occasional glimpse is caught of the talipot palm, one of the most noble objects in the vegetable kingdom.

The sugar-loaf top of Adam's Peak soon comes into the view rising to a height of 7,352 feet above sea level, being the fifth highest peak in Ceylon, and not long afterwards the double-headed Allagalla mountain also shows itself, and, the real climb having now commenced, a second engine is attached to the train, which, owing to the ascent being now 1 foot in 45 feet with curves round the mountain side of some 600 feet, proceeds at the slow rate of about 12 miles an hour. This, however, has its compensations, since you are able to note the exquisite mountain, valley, woodland, and homestead scenery, with the view into the famous Kandy Pass 1000 feet below. Conspicuous also in the Dekanda Valley are the terraced rice fields and the silvery foliage of the Kekuna tree, *Canarium zeylanicum,* while the purple flower spikes of *Lagerstroemia* attract attention. On the hill-sides large rubber plantations are interspersed with delightful natural scenery down which waterfalls tumble and glisten in the bright sunshine, and give a refreshing cooling effect.

Finally, after crossing a bridge which spans the Mahaweli-ganga, New Peradeniya station is reached, and, leaving the train, you are in a short time within the Royal Botanic Gardens, Peradeniya. These famous gardens were opened in 1821—six years after the fall of the Kandyan kingdom—and are part of land which belonged to a royal demesne. They are 146 acres in extent, are ideally situated on undulating ground in a loop of the Mahaweli-ganga, with the shadow of the Hantane mountain rising 4,100 feet in the near distance, and have much natural beauty, added to by the excellent landscape work of its several distinguished directors—*Thwaites, Trimen, Willis,* now being continued under the Hon. *F. A. Stockdale.*

Part of the early work of Peradeniya was concerned with collecting and describing the native flora which is now contained in the excellent herbarium and museums within the garden, and in the publication of a "Flora of Ceylon" dealing with the flowering plants in 1900.

Simultaneously with this work the garden occupied itself with the introduction and acclimatization of the useful and ornamental plants of other countries. In this way cinchona, cacao, rubber, coffee, and vanilla were introduced as plantation crops, and the extension of the cultivation of tea, cloves and nutmegs was much helped.

Fine old examples of these early introduced economic plants are still to be seen in Para rubber; a giant brazil nut tree; specimens of the nutmeg, now 100 years old and still bearing fruits; cinnamon, allspice, cloves, and cassia bark, all represented by large examples.

Near by is a younger plantation of economic plants of various kinds which includes *Taraktogenos Kurzii,* the oil from which is now used in the East for curing leprosy. It was of interest to note the rapid growth this collection had made in the short time since it was planted.

The main entrance to the gardens on the Colombo-Kandy road is conspicuous for the magnificent row of *Amherstia nobilis* to the right, and the large oil palms just within the gates. The piers of the gates are covered by *Bignonia.*

Arranged in sections, which are lettered and planted systematically, it is easy to find any group of plants the visitor may be interested in. The palm collection as one would expect is very extensive and contains a good example of the interesting double coconut—*Lodoicea sechellarum,* and the

sealing-wax palm *Cyrtostachys Renda* attracts attention by the brilliant colouring of its sheathing leaf-bases. Crowning an eminence was a very fine flowering Talipot palm (*Corypha umbraculifera*), and not far away by the lakeside the giant bamboo, *Dendrocalamus giganteus*, was raising its culms 120 feet high, being closely followed by *Gigantochloa aspera* which reached 80 feet to 100 feet high, both a contrast to the Japanese *Bambusa nana* which only grows a few feet and is largely used here and elsewhere in the tropics as a hedge plant.

In the lake itself the sacred Lotus lily (*Nelumbium speciosum*) has become a pest, and has to be kept within bounds so as not to kill out the many other smaller water things planted near the margins.

The herbaceous garden is planted much on the same lines as in our own botanic gardens, the most convenient from the student's point of view. It contains a wealth of beautiful flowering dwarf plants which would be lost among the taller growing things in the other collections.

Peradeniya has a good collection of the more interesting conifers, one of which, *Araucaria Cookii*, grows to a height of 120 feet: *A. Bidwillii* also reaches a great height, so does the Moreton Bay pine *A. Cunninghamii*. Among the Cupressus were *C. macrocarpa*, *C. funebris*, and *C. Knightiana*. *Agathis robusta* also makes giant trees here; so does the Malayan *Podocarpus cupressina*; and *Gnetum Gnemon* flowers and fruits.

Among other interesting trees I noted *Michelia Champaca*, the flowers of which are used for decorating ladies' hair, and also as a Buddhist temple flower: *Magnolia grandiflora*, 50 feet high; *Cananga odorata* which gives a perfume much used by the Chinese: *Berrya Ammonilla* from which is obtained the Trincomale wood much sought after by cabinet makers for its beautiful markings; *Diospyros* with wood taking a brown polish and black spots; *Mallotus philippinensis* with weird corrugated stems and a good timber tree; *Pterocarpus santalinus*, the santal wood; and a big Mango 150 feet high. *Bassia longifolia*, a native tree of Ceylon yielding oil much used by the natives for rheumatism, was just opening its soft pink buds. *Wormia Burbidgei* 20 feet high was covered with its yellow flowers, and so were several species of *Brownea* with their brilliant scarlet panicles.

Several climbing plants not common in our gardens were seen in perfection: notably *Congea tomentosa* with long loose sprays of mauve-pink velvety bracts; the tropical American *Petrea volubilis* with mauve and pink racemes; *Odontadenia speciosa* from South America; *Camoensia maxima* from tropical Africa with large white scented flowers, *Ipomoea*, *Porana*, *Roupelia*, *Thunbergia*, *Wagatea*, and many others. Indeed, a special feature is made here of climbing plants noted for their beautiful flowers and bracts. The collection of Bougainvillaeas contains some very beautiful examples of the latter.

The section of the garden devoted to fruit-bearing trees contains Mango, Sapodilla, Rambutan, Loquat, Java Almond, Litchi, Anchovy Pear, Grape Fruit, Mangosteens, and many others.

One of the most showy of the larger trees in flower was the scarlet flowered *Spathodea campanulata* of tropical West Africa, and, possibly the most interesting, a plant 35 feet high of the Brazilian composite *Stifftia chrysantha*. One might go on describing the wealth of interesting trees and plants to be found in Peradeniya, but this would occupy the whole of my time.

Leaving Peradeniya, I took the train for Nuwara Eliya, which is 6,200 feet above sea level and which, as I mentioned before, has an average temperature of 58° and an occasional frost.

The train journey is one of great interest and beauty, as the line runs through a large planting district and mile after mile of tea gardens occupies the mountain sides. Many of the railway stations are themselves pictures of floral art; one of these had a fence clothed with the "Morning Glory" (*Ipomoea rubro-coerulea*) covered with its delicate blue flowers. Bougainvillaeas and Allamandas are also much used for this purpose, while at Watagoda, *Datura suaveolens* had escaped for some distance on either side the station and its white chalices suspended in profusion from its branches—an ever to be remembered sight. Lantanas were very common everywhere.

I was intrigued to see the Cuban hemp (*Furcraea gigantea*) apparently wild all along the line for several miles. This I later discovered was planted some years ago by a Fibre Company who obtained a concession from the Government to use the land for a certain distance on either side the line for growing its fibre-producing plant.

At the junction Nanu Oya, where the line is continued to Nuwara Eliya by a toy train, I was met by a friend's car and did the last part of the journey through the pass, which is very beautiful. Here and there, standing like sentinels, was the giant *Lobelia nicotianifolia,* the beautiful native tree fern *Alsophila crinita* and the lesser *Hemitelia Walkerae,* while now and then one saw large colonies of the Ceylon daffodil (*Ipsea speciosa*), interspersed with *Exacum zeylanicum.* Large plants of *Rhododendron arboreum* were common.

Nuwara Eliya stands in an amphitheatre of hills and is largely used as a health station. The Governor and the Colonial Secretary have residences here, attached to which are very interesting gardens in which are grown many annuals common to English gardens, such as sweet peas, antirrhinums, etc. Carnations also do very well, and the pretty *Dierama pulcherrimum* was almost a weed, but is very valuable for its cut flowers, which travel well. The gardens have a special interest for the large number of fresh vegetables, which are grown in them to be sent down to Colombo—peas, beet, carrots, leeks, cauliflowers and artichokes being the chief kinds which succeed.

There is also a large public park in which many good things are to be found. Several kinds of roses flourish, and some of the Australian Acacias and Eucalyptus make large trees. In fact, on the hills about Nuwara Eliya *Acacia melanoxylon* is one of the chief trees planted because of its great value for firewood, the chief trouble with it being to keep it clear of the semi-parasitic mistletoes which appear to be partial to it.

In the park is a very fine avenue of *Cupressus macrocarpa* which gives welcome shade on bright days, and all about on the hills are huge specimens, 30 to 40 feet high, of *Rhododendron arboreum.*

My next stage took me to Hakgala Gardens, six miles south-east of Nuwara Eliya on the Badulla road, 4,100 feet above sea level. These were started in connexion with Peradeniya in 1861 as a hill station for growing Cinchona, and many of the older plantings are from seedlings raised here and afterwards distributed to the planters.

In 1882 Mr. William Nock was appointed superintendent, and he began to lay out part of the estate as a botanic garden, and largely increased the cultivation of other useful and beautiful plants of which Hakgala bears witness today. The present area under cultivation is 55 acres out of 500 acres which are available for development.

The garden faces due east and has an imposing back ground, the Hakgala rock, whose highest peak rises 1,400 feet above the garden. This rock is clothed with *Rhododendron arboreum* in two colour forms. Much experimental work is being carried out at Hakgala in the acclimatization

of exotic trees which are likely to be of value as timber trees, and many of the Australian Acacias and Eucalyptus are already showing their suitability for this purpose. Others are being tried for their economic products, such as the bark for tannin, etc. A large section is also devoted to grasses and other fodder plants with a view to their suitability for feeding purposes on the barren patanas.

From this point on a clear day, a view of 40 miles can be obtained over magnificent mountain scenery upon which the limits of cultivation are clearly discerned. Some years ago the Government passed a law that all land above 5,000 feet should be reserved for the native fauna and flora. It is true that there are areas of cultivation above this elevation, but they are those which had been sold previous to the passing of the Act, and are chiefly under tea, which is used to increase the flavour of the tea produced at the lower elevations.

Mention must be made of the very interesting collection of native plants which have been collected by Mr. Nock and planted in a special section of the garden. Among them I noted *Ipsea speciosa, Viola serpens, Exacum macranthum, Impatiens Hookeri* with handsome white flowers veined with red, *Lobelia excelsa, Spilanthes Acmella, Arisaema Leschenaultii, Satyrium nepalense, Phaius Wallichii, Eria bicolor, Calanthe veratrifolia,* and the pretty little skullcap *Scutellaria oblonga.* On the trees were *Dendrobium nutans* and the sweet-scented *D. heterocarpum; Lycopodium squarrosum* and *L. serratum* were also plentiful. No where have I seen so good a collection of the forms of *Begonia Rex* as at Hakgala, where they revel in the moist conditions. The fernery is also a special feature: and besides many noble specimens of *Alsophila crinita* and *A. glabra* the native tree ferns, there are good examples of the Australian *Alsophila Cooperi* and *Dicksonia antarctica,* and the New Zealand *Cyathea dealbata.*

Fuchsia arborea, which is known as the Ceylon lilac, and the Peruvian Fuchsia *F. corymbosa* (two plants which years ago used to be seen in our green houses, but now alas rarely met with) were seen in large bushes. *Brunfelsia uniflora* also made a very showy border plant, as did *Salvia leucantha* and *S. farinosa* which was represented in two forms, one of which had deep violet flowers.

Many annuals are grown at Hakgala for decorative purposes, but owing to the ravages of surface caterpillars they have to be protected in the young stage with paper collars placed around each seedling.

Among economic plants are good trees of *Syncarpia glomulifera,* the New South Wales turpentine tree, also useful as a timber tree; *Pinus longifolia,* which gives a good resin, and the bark used for its tannin and for fuel for smelting iron, *Juniperus bermudiana,* the pencil cedar; *Eucalyptus globulus,* from which oil is distilled from its fresh leaves; *Tristania conferta,* a good shipbuilding wood; a very large specimen of *Cinnamomum Camphora,* from which camphor is distilled from leaves, twigs and roots; *C. Cassia of South* China and Burma, the source of the "Cassia buds" of commerce used as a spice in confectionery; the Black Guava *Psidium Cattleyanum,* the fruits of which are here produced twice in a year and used for jelly making; *Sapindus saponarius,* the seed vessels of which are used as soap and the seeds as buttons: *Citrus buxifolia* the marmalade orange, which annually gives good crops of fruit; and the mountain Papaw, *Carica candamarcensis,* the fruits of which are used for stewing, but are not used as dessert like those of *C. Papaya.*

Several hours were spent in the jungle which adjoins the garden, where numbers of small filmy ferns and mosses clothe the small undergrowth, and many epiphytic orchids (*Eria, Dendrobium, Coelogyne*) abound; whilst making a natural carpet was *Selaginella brachytachya.*

CARDAMOM.

(*ELETTARIA CARDAMOMUM* MATON).

(*S.* ENSAL; *T.* ALUM.)

Department of Agriculture, Ceylon, Leaflet No. 56.

THREE varieties of cardamom are found in Ceylon :—

(*a*) The *indigenous* which grows wild in wet forests up to an elevation of 3,000 ft., and is found especially in the Ratnapura District; its produce is of inferior value;

(b) The *Malabar* (rata ensal), largely grown in the Kandy District;

(*c*) The *Mysore*, which grows best at elevations of 2,000 to 4,000 ft., is more robust and stands wind and exposure better.

The Malabar and Mysore cardamoms are two distinct types, while the Ceylon indigenous variety is considered to be a type of the Malabar cardamom. The following characters show the differences between the two types :—

Mysore : Leaves large and coarse; dark green, undersurface not velvety and soft but hard and smooth; flower stalks borne perpendicularly, do not spread on the ground; fruit elongate and rarely cornered.

Malabar : Leaves silky on the undersurface; flower stalks spread along the surface of the ground; fruit shorter and more globular.

The indigenous variety differs from the Malabar in possessing coarser leaves which are less silky on the undersurface, a stem which is distinctly tinged with pink, a short and sparsely-flowered inflorescence, and a fruit which is long.

CLIMATE, SOIL, AND HARVESTING.

The main requirements of the cardamom are (*a*) shade, (*b*) protection from wind, (*c*) abundant moisture, (*d*) a rich loamy soil. Moist hollows, ravines, and the banks of streams are favourable situations. It is essential, however, that the plantation should be well sheltered from the wind. Shade is required, but it should be chequered, so as to admit of a fair amount of light and air. The growth of cardamoms is slow when shade is too dense.

The rainfall may be 100 in. or more, but it should be well distributed throughout the year. Excessively wet conditions, however, are unfavourable. Flat land which is liable to remain too damp should be drained, but on sloping ground there is no necessity to lay drains, as soil-wash seldom occurs under the conditions existing in a cardamom plantation. The soil should be a rich, fine loam. A clayey soil is not suitable as it is too stiff and tends to remain excessively wet, while a sandy soil does not retain sufficient moisture.

It is usual to establish a cardamom plantation in a partially cleared forest. The undergrowth is removed but only so much overhead shade as is sufficient to admit light and air. Cardamoms are planted in holes at a distance of 7 ft. by 7 ft. on rich land and 6 ft. by 6 ft. on inferior soil.

The holes should be 1½ ft. to 2 ft. square and 12 to 15 in. deep. After being left for a week to ten days after opening, they should be filled with fine surface soil which has been freed from stones.

After planting out, little attention is needed. Weeding is necessary once in two months for the first two years, but when the bushes have formed fully the weeds are kept down. When the plants begin to throw out racemes, the bushes should be cleaned. Decayed and dry leaf-stalks may be pulled away from the stool. Damaged or decaying stalks should be cut off at a height of 2 to 3 ft. from the ground; if cut at ground level they are liable to set up decay of the root-stock. The first crop, which should be a small one, may be expected in the third year; a full crop is obtained in the fifth year, from which time profitable returns will continue for five or six years. A plantation begins to decline from the fifteenth year. The bushes bloom all the year round, but chiefly from January to May. Picking takes place generally once in three weeks during the period September to April, the busiest time being in December.

The fruits are borne on racemes, which bear at least for a second season. In harvesting, therefore, the racemes should not be stripped off, but only individual fruits picked with the aid of a pair of scissors. Particular care should be exercised during picking in order not to damage the blossoms which are present at the same time as the fruit. From the time of flowering the first crop on a raceme takes five to six months and the second three to four months to ripen.

Fully ripe fruits assume a deep yellow colour, but it is difficult to cure them properly as they split during drying. It is necessary, therefore, to pick the fruit just before it turns yellow. The yield under favourable conditions may be 150 lb. per acre in the fourth year and as much as 300 lb. in the fifth year. From the third to the tenth year the average annual yields per acre may be taken as 100 to 200 lb. After the fifteenth year the average yield may be from 40 to 80 lb. per annum.

One of the main causes of deterioration of a cardamom plantation is non-replacement of shade which may become reduced through natural agencies.

PROPAGATION.

(*a*) A common method of propagation is the use of sections of the root-stock which are popularly termed "bulbs." Small "bulbs" are generally used. It is preferable to dig up the whole of a particular block, which may be looked upon as the nursery, rather than remove the "bulbs" from individual clumps. Care should be taken not to keep "bulbs" for a long time before planting, nor to set down "those" which are damaged in any way, as it is possible they may decay. In order to obviate risk of losses by planting single bulbs, it is advisable to put down what are termed double bulbs. The latter consists of two stems connected together with one or more shoots springing from their bases. They should not be planted too deep nor merely placed on the surface of heaped soil in the pit but should be inserted in the soil in such a way that the lower end of the stem remains above ground. The soil should be carefully pressed down by hand; it should not be trodden down by foot.

A new plantation may also be established by planting out whole plants severed from a clump. The leaf stalk is not cut off, and the plant is placed in the soil in a sloping direction at an angle of 30° to the ground. New shoots develop vertically from the stock.

(*b*) Propagation by seed is a more economical method. Great care, however, is necessary in raising nurseries, as the tender seedlings are very susceptible to damping off. The Mysore variety forms a more successful

nursery and stands transplanting better than the Malabar. At lower elevations seed may germinate in three weeks, but at elevations of 4,000 ft. it may take as many months. Only fully ripe fruit which is of a distinctly yellow colour should be picked for seed purposes. The fruits should be removed separately and the seed squeezed out of the capsule. The seeds are present in an agglutinated mass, and should be exposed to the sun for a little while or should be air-dried. When they can be separated easily, they should be soaked in water for a few hours and sown thinly in a carefully prepared nursery bed consisting of sand and fine leaf mould. A good overhead covering is necessary to protect the bed from excessive heat and rain. As damp alone is sufficient for germination, water should be given sparingly.

Two lb. of fresh fruit should give ½ lb. of dry seed which is sufficient for planting up one acre. The seed rate needs to be high as only a small proportion germinates as a rule.

PESTS AND DISEASES.

Squirrels and rats may cause much destruction by feeding on the fruit, while porcupines and monkeys damage the stools. The cardamom borer, *Lampides elpis*, is the pinkish caterpillar of a blue-coloured butterfly which lays its eggs in the flower. The caterpillars feed on the flowers and seeds, and, having pupated in the fruit, ultimately emerge through a small hole in the shell of the empty capsule.

The death of cardamoms in clumps in the field has been shown to be due to a root disease caused by a soil fungus (*Rhizoctonia bataticola*).

PREPARATION FOR THE MARKET.

Curing is effected in dry weather by exposure to the sun. Over-exposure should be avoided as it causes the seeds to swell and to burst the capsules. In dry weather, exposure for three hours in the morning and two in the afternoon is sufficient. The slower the drying, the smaller the proportion of split fruit. During wet weather slow drying is effected by gentle artificial heat on trays, but the product is brown in colour and accordingly of less value. The colour may be improved by sun-bleaching the capsules after sprinkling with water, but this process increases the amount of split fruit.

In artificial bleaching the cardamoms are subjected to sulphur fumigation and alternate periods of drying. Under satisfactory conditions the whole process is completed in from ten to twelve days; if the weather is unfavourable, bleaching takes a longer time.

The sulphur box should be airtight. Its size varies with the quantity of crop to be dealt with. The cardamoms are spread on jute hessian or bamboo tats or trays, and not more than 25 lb. should be spread over 6 to 8 sq. ft. There should be a space of at least 1 ft. between the bottom of the box and the first tray. The burning sulphur is contained in a tin saucer and is placed in the bottom of the box.

First stage: ¼ lb. sulphur is used for every 100 lb. of green cardamoms. To get the best results, it is preferable to place the cardamoms in the box in the evening and leave them overnight. On the next morning the capsules are spread out to dry in the sun; in favourable weather drying should occupy three days.

Second stage: The cardamoms are next immersed in water and allowed to soak for three to four hours. They are then placed in the sulphur box for a fumigation for which 2 oz. of sulphur are used for every 100 lb. The fumigation should last for one hour or a little longer, and after it is over the cardamoms are sun-dried again. On a bright day seven hours' drying should suffice.

Third stage: A repetition of the second stage with the exception that the period of soaking is reduced to between two to three hours, and the quantity of sulphur used is 1 oz. for 100 lb.

Fourth stage: A repetition of the third stage with only ½ oz. of sulphur used on this occasion.

The final drying in the sun should be carried out carefully. If the capsules are allowed to dry quickly and completely, a large proportion of them may shrivel. The crop should be taken in when the capsules are about three-fourths dry, and it should be spread indoors in layers to dry slowly.

It is necessary to clip and grade the dried cardamoms before packing. Clipping is the removal of the stalk at the base and remains of the calyx at the apex of the capsule. When done by hand it is an expensive and laborious process; it may be carried out by a machine.

The fruit is graded by means of sieves of three sizes, and at the same time sorting for colour and the removal of split capsules are carried out. Perfectly cured cardamoms are of a light straw colour. The market value of the finished product is decided by size, plumpness, colour, and smoothness. Bold long fruit contains a higher proportion of seed and less shell than smaller capsules. Split fruit is less valuable owing to loss of seed and aroma. The out-turn of bleached fruit is 19-21 per cent. and of ordinary dried fruit 22-24 per cent. of the green produce. The finished article is packed in momi-chests lined with blue or brown paper.

The price of Ceylon cardamoms has varied as follows between 1922 and 1926:—

	Average Price per lb. Rs. c.	Highest Price reached. Rs. c.
1922	1 54	2 25
1923	2 41	3 0
1924	2 92	3 80
1925	3 42	4 0
1926	2 44	4 0

The amounts exported and the value of the produce from 1922 to 1926 have been as follows:—

	Quantity Cwt.	Value. Rs.
1922	4,096	549,669
1923	2,784	563,557
1924	2,665	696,927
1925	3,299	1,148,831
1926	2,845	841,961

It is estimated that the cultivation of cardamoms in Ceylon occupies 6,324 acres, of which 5,000 acres lie in the Central Province (Rangala, Urugala, Laggala) and 1,000 acres in Sabaragamuwa (Balangoda).

THE WORLD AGRICULTURAL CENSUS OF 1929-30.*

REFERENCES have already been made to the proposal of the International Institute of Agriculture that an Agricultural Census should be taken throughout the world in 1929-30. Great progress has been made in the furtherance of this idea, and it may be of interest to summarize the present position.

The need for a World Agricultural Census was particularly felt after the war, and in May, 1924, the Institute was authorised to take steps to induce the adhering Governments to carry out a general Agricultural Census in accordance with a uniform plan to be prepared by the Institute. This proposal attracted the attention of the International Education Board (Rockfeller Foundation), which made a grant of $10,000 per annum for the five years 1925-29, to be used to defray the salaries of a Director and an Assistant Director and the travelling expenses involved in visiting the various Governments. A special Bureau charged with this particular work was created at the Institute in 1925, and Mr. Leon M. Estabrook was appointed as Director of the census project. Mr. Estabrook is an officer of the United States Department of Agriculture, and possesses an intimate and technical knowledge of methods of collecting and dealing with agricultural statistics. In addition to his experience in the United States he had, before his appointment to the Institute, been entrusted with the task of reorganizing the agricultural statistics of Argentina, and he was therefore specially qualified to fulfil the duties which the new undertaking involved.

After some preliminary investigations, a standard form for use in the collection of the Census was prepared, and this form was considered and revised in the first instance by a committee of the International Scientific Council of the Institute in February, 1926, and subsequently by the Committee of Statisticians of the General Assembly in the following April. The standard form of schedule was circulated to all Governments, together with explanatory information as to the value of the Census, the recommendations of the Committee of Statisticians in regard to the way in which the Census should be taken, and similar matters.

Following on this Mr. Estabrook was charged by the Institute with the mission of visiting the different countries of the world in order to interest them in the taking of the Census and to discuss details with the statistical authorities.

It would be difficult to overestimate the importance and utility of this part of the work, which, indeed, constitutes the main contribution which the Institute has been able to make to the preliminary work of the Census. By these personal visits and interviews the proposal has been put before the competent authorities in a way which would have been quite impossible by correspondence. The reports received from Mr. Estabrook on his visits show that he has been received everywhere with the greatest courtesy, and that on every side there is a general disposition to make the Census a success. During the past two years many Conferences and Congresses have expressed their approval of the idea, and among these special reference may be made

* By R. J. Thompson, C.B., O.B.E., in *The Journal of the Ministry of Agriculture*, Vol. XXXV, No. 9, December, 1928.

to the resolutions of the World Economic Conference organised by the League of Nations in May, 1927, and of the Imperial Agricultural Research Conference in London in October, 1927.

Recently (October, 1928) a further gathering of the Committee of Statisticians was held in Rome, and various questions relating to the World Census were discussed. This Committee, which sat for several days, was attended by representatives of over thirty countries, and made a number of recommendations which will in due course be included in a revised edition of the standard form.

The Committee had the advantage of receiving from Mr. Estabrook, the Director of the Census, an account of the results of the visits he had made during the past two years to the various countries of the world. Mr. Estabrook reported that since June, 1926, he had visited all countries of the world except Albania in Europe; Persia, Afghanistan and Mesopotamia in Asia; some of the Colonial territories in Africa; Central America; and five countries of South America. He expected to visit Albania, Central America and the northern countries of South America within the next few months. In all the countries so far visited the responsible officials had expressed a desire and a willingness to co-operate as far as practicable in the World Census. In addition useful information has been obtained concerning the statistical services and the organization of Agricultural Departments while the Colonial Departments of Great Britain, France, Belgium, Italy and Portugal had expressed a willingness to co-operate by bringing the proposed Census to the attention of their Colonies and Dependencies.

The countries visited include 76 per cent. of the land surface of the world, more than 90 per cent. of its population, and an even higher percentage of its agricultural and live stock production.

In relation to the collection of a uniform Census, the striking feature of the tour was the diversity of the agricultural conditions throughout the world. Soil and climate, crop and live stock, farm practice, transportation, marketing and distribution, all differed, and, in view of this fact and of the varying degree of agricultural and statistical organization, it is considered highly necessary that the proposals in the standard form should be kept as simple as possible, each country being free to obtain as much additional information as might be desired.

The preparatory work has thus been nearly completed, and it now remains for the Governments to give effect to the scheme by completing their arrangements for the taking of the Census in 1929-30. Many practical problems are likely to arise, and the personal interviews which the Director of the Census has had with the statistical authorities of the different countries are likely to bear fruit in the shape of demands for advice and assistance. There are many countries where the collection of an Agricultural Census is an established practice (*e.g.*, Great Britain, United States, etc.), and with these the Institute will not be much concerned. There are, however, others where a Census has never been taken in the past, or has not been taken for many years, and much of the value of the scheme lies in the possibility of inducing these countries to take a Census and thus provide both themselves and the world at large with information which is now lacking.

Looking further ahead, the Institute has to consider what is likely to be the position when the Census has been taken. It will be the business of each country to publish a summary of the principal results as early as possible, and to follow this up with a report in more detail, providing a sound view of the agricultural conditions of the country concerned. It is hoped that each country will furnish the Institute with the preliminary

results of the Census as they are obtained, and thus enable the Institute to publish, month by month, information as it becomes available. By this means all who are interested in the world's food supply, from whatever point of view, will be able to utilise at once such part of the information as is of value to them, without waiting for the publication of the full reports of each country. The Institute will incorporate the information in the international agricultural statistics published in the Statistical Year Book, and in the tables relating to crop and live stock production published in the Monthly Bulletin.

But this is only one stage. The main and essential function of the Institute is to study the international production of food and raw materials, and to correlate the information as to supply with the demand and consumption of the different countries, so that we may have increased knowledge as to the balance of supply available from those countries which have a surplus, and the probable demand from those countries where the output is insufficient for requirements. There is here a wide field for investigation. In the case of a few important products, such as wheat and cotton, statistics of world production are closely studied and are of practical utility in regulating the direction and movement of supplies and the formation of prices. In the case of many other agricultural products, however, information is very defective, and it is particularly in regard to those that the results of the World Census are likely to be of value. Each commodity needs to be studied separately, and to be investigated not merely in regard to the past but to probable future development. It is necessary to consider whether the world's supplies of foodstuffs and raw materials are increasing proportionately to the growth and purchasing power of the population, and how far they may be limited or increased in the future by changes in methods of cultivation or in the area of land available. If the Governments of the world carry out the Census effectively they will be making a great contribution towards the provision of material on which such investigations can be based.

To enable the Institute to carry out the investigations, and to secure from the Census the results of world-wide importance which should be obtained, it will be necessary to provide funds to secure the services of a highly qualified and efficient staff.

Up to the present the main cost of the work connected with the Census has been met by a grant, already mentioned, made by the International Education Board. This grant is due to end in 1929, but at the recent meeting of the General Assembly of the International Institute, the Assembly, while thanking the Board for its past assistance, expressed the hope that "the International Education Board would continue this assistance in future years so as to enable the work which has been so successfully begun to be brought to a satisfactory conclusion."

MEETINGS, CONFERENCES, ETC.

TEA RESEARCH INSTITUTE OF CEYLON.

MEETING OF BOARD.

A meeting of the Board of the Tea Research Institute of Ceylon was held in the Chamber of Commerce, Colombo, on December 13th, the minutes of which are now issued.

There were present:—Mr. R. G. Coombe (Chairman), the Hon. the Colonial Treasurer, the Hon. Mr. J. W. Oldfield, Dr. W. Small (Acting Director of Agriculture), Messrs. E. C. Villiers, H. F. Parfitt, John Horsfall, P. A. Keiller, J. D. Finch Noyes, D. S. Cameron, A. W. L. Turner (Secretary); and by invitation Dr. C. H. Gadd (Acting Director, Tea Research Institute of Ceylon).

The Chairman, reviewing the statement of the accounts to November 30th, 1928, mentioned that two statements had been made out, one dealing with the usual research expenditure and the other in connexion with the loan from Government.

In the first account there was a balance of Rs. 398,636·11 of which Rs. 370,000 was represented by fixed deposits until early in July next, and Rs. 25,251·58 cash in the bank on current account.

Turning to the second account: Rs. 350,000 had been placed on fixed deposit till March 29th (6 months) at 3½ per cent., the balance on current account.

He regretted that it was not possible to present the estimates for the various buildings to be erected on the estate, due to the unexpected delays in taking possession of the estate. He intended to call further meetings of the estate sub-Committee on the morning of January 8th, to deal with them, to be followed by a Board meeting on the same day.

The draft estimated Research expenditure for 1929, was submitted for the Board's consideration.

Referring to the item "calculating machine," the Colonial Treasurer expressed the opinion that unless there was 3 or 4 hours' work per day, it would be better to do the work by human calculation.

Dr. Gadd said that there was a great deal of calculating to do, and it had to be done by the scientific staff. The request for the machine was made in order to give the staff more time to devote to research. He considered the machine to be essential. The vote was then agreed to.

It was proposed by Mr. Finch Noyes and seconded by Mr. John Horsfall that subject to the alteration in connexion with the grant to the Planters' Association the estimates be adopted.—The meeting agreed.

Alluding to the future policy of the T.R.I., the Chairman stated that recently there had again been a good deal of criticism with regard to the work of the Institute and its future policy.

The Institute was, he felt, doing all it could under present circumstances. He thought that a Conference might help matters. He had consulted Dr. Gadd, and it was thought that a Conference should be held in March, in conjunction with the Planters' Association meetings.

He suggested that the Conference should be held on Monday, March 11th, at Peradeniya; and should consist of two sessions at 9·30 a.m. and 2·30 p.m. at which papers could be read by members of the Scientific Staff.

The accounts and the annual report would be presented at that Conference.

Mr. Villiers felt that a conference was most essential, and would go a long way towards disarming public criticism.

It was agreed that a conference should be held on March 11th next.

The Hon. Mr. J. W. Oldfield said that he brought the proposal forward last year, and he was of the opinion that persons not connected with the institute should be invited to read papers, such papers to be submitted to the Board for consideration prior to the conference.—This was agreed to.

The Chairman said that the Board had agreed at its last meeting that the loan of Rs. 1,000,000 from Government should be taken up. This was done on September 29th.

PROGRESS REPORTS.

The following Director's review of the reports for September, October and November was taken as read :—

"The Mycologist has made further analyses of the wood of tea roots to determine the amounts of starch and sugars in heatlh and 'Diplodia' bushes. So far, the results confirm the observations from qualitative tests already reported.

"Failure to recover from collar pruning is, in many cases, the result of a defficiency of food reserves within the roots. Such failures are likely to occur in fields where deaths commonly occur after normal pruning. The presence of starch within the roots, however, is not a sure indication that the bushes will recover rapidly, if collar pruned. A number of bushes, which were collar pruned in July, were examined in the middle of November, as by that time growth had not started. The roots were alive and healthy; no die-back had occurred from the cut, and starch was present in all the roots. The reason for the delay in growth is not apparent, but so long as the roots remain alive there is a possibility of new stems being formed. The physiological processes which culminate in new growth after pruning are complex and dependent on several factors, one of the most important being the availability of reserve foods.

"Very few outbreaks of the Cercosporella leaf disease occurred during the South-West Monsoon this year, and those were ralatively mild. Fructifications ('perithecia') similar in appearance to those obtained in pure cultures of the fungus 'Cercosporella Theae' were found on one occasion on dead tea leaves killed by this disease. Unfortunately, no spores could be found, so accurate identification was not possible.

"A new leaf disease of mature tea has been found in several fields of an estate in the Kalutara District, and with which was associated the fungus 'Corticium vagum' ('Rhizoctonia solani'). This fungus has been reported on tea only once previously, and then it was associated with a disease of seedlings in the same district. The field evidence strongly supports the conclusion that 'R. solani' is the causal fungus, but inoculation experiments on tea seedlings in the laboratory at Nuwara Eliya failed to give positive results.

"The fungus is quite common in Ceylon soils, and is well known as a disease of seedlings of many species. For some years it has been known to be the cause of a serious leaf disease of Vigna ('Dolichos Hosei') in the Low-country. On tea the fungus reaches the leaves via the stems, along which it grows as fine strands, and it causes no injury until it spreads over the leaves as a fine weft. In this respect the disease resembles that known as black rot 'Corticium invisum.'

"Complaints have been received concerning the poor germination of tea seed from certain estates. Investigations have shown that the seed is healthy, and that germination is delayed by some character of the shell, its hardness, thickness or impermeability to water, rather than by any fault in the germ itself. When the coats (shells) are removed from the seeds, the rate of germination is greatly improved.

"Experiments have been made to determine the rate of growth of 'Poria hypolateritia,' the cause of a serious root disease of tea, through soils of different reactions. The experiments demonstrate that an application of lime at the rate of 5 tons per acre results in an increase of the growth rate of the fungus, and even 15 tons per acre has no beneficial effect. There is no reason to believe that lime has any effect in the treatment of root diseases other than the change it causes in soil reaction. In this case, the change proved beneficial to the fungus. In view of this experiment and of the observations made in the field, the use of lime in the treatment of this disease is not recommended.

"The soil reaction values of the above experiment were determined by the Soil Chemist. They ranged from 4—8 on the pH. scale, i.e., from conditions of great acidity to that of pronounced alkalinity, agriculturally. The general tendency was for the fungus to move the reaction value to a position of equilibrium on the acid side of neutrality. The part played by fungi in the decomposition of vegetable residues is well known, and these results indicate how the reaction of partially decomposed organic residues tends to be controlled in the process.

"Further progress has been made in the basic exchange studies of the soils. The rapid rate at which losses of exchangeable bases occur from soils under tropical conditions is illustrated by the following observations. Two soils, which differed only in that one had twelve months previously received a ton of lime per acre, showed no difference, either in the total quantity of exchangeable base or in the quantity of exchangeable calcium. Since neither soil contained free calcium carbonate, the results show that within the period stated the whole of the lime had been removed from the surface layers of the soil, that all calcium ions which had entered the soil colloid complex as a result of the application of lime had disappeared, and that the original equilibrium within that complex had been re-established. This observation possibly affords an explanation of the tentative conclusion previously reported, viz., that calcium does not supply such a large proportion of exchangeable bases to the total sum, as is usually the case in well-conditioned temperate soils. The heavy rainfall to which tea soils are subject offers an adequate explanation of this heavy loss.

"In order to extract as much information as possible from the leaf samples obtained from the Uniformity Trials, the soil chemist has undertaken the analysis of these for the two plant nutrients, potash and phosphate. The nitrogen determinations are made by the Biochemist. The complete data are of interest to both chemical divisions. The results will give indications of the rates of nutrient uptake which may be correlated with yield increments and with climatic conditions. No importance attaches to the actual gross amounts of nutrient elements taken from the soil as such quantities have little bearing on the amounts of these substances required as manures, but a study of the rates of uptake has a real bearing on manurial practice. Such data are not available in the Ceylon literature.

"A sample of a highly adulterated ground fish product, sold as manure locally, was found to contain 50 per cent. insoluble material, mainly sand, the nitrogen and phosphate contents were so low as to make the manure unsatisfactory and expensive in comparison with the standard article. In the absence of guaranteed analyses, the buyer has no redress; as the buyers of such supplies are normally the village agriculturist, the necessity for legal protection is apparent.

"Work has been continued on the Uniformity Trial; six pluckings have been made in the three months.

"The Biochemist has continued his investigations of the seasonal changes in the green leaf as plucked, samples for analysis being obtained from the plots of the Uniformity Trial. The onset of North-east monsoon conditions has resulted in lower figures being obtained for the components estimated, though the different components are affected equally. The effect of continuous wet weather appears to be cumulative as the soluble matter of the leaf of successive plucks tends to decrease continuously. The same tendency has been noted regarding the total nitrogen of the leaf, the nitrogen in the extract, and the non-tannin portion of the extract. The tannin content of the extract shows a big variation from pluck to pluck, but the tendency to become uniformly less during spells of wet weather is not so evident. Confirmation of these observations will be obtained by regular analyses such as are being made.

"Progress has also been made with the investigation of the changes which occur during withering. During withering, not only is water lost from the leaf, but a part of the solid matter also disappears as a result of the respiratory changes which take place. The amount of solid matter lost in this way is appreciable and must be taken into account when interpreting the results of chemical analyses.

"It would appear from the table that an increase of soluble material occurred in both samples of leaf during withering. When the analyses are corrected for respiratory losses, it becomes evident that no real, appreciable increase in quantity of the extractable materials had taken place.

	Ext. uncor. p.c.	Ext. cor. p.c.	Alc. sol. p.c.	Alc. insol. p.c.	Tannin. p.c.	Nitrogen in ext. p.c.
Fresh leaf	38·5	38·5	35·88	2·92	14·65	1·64
Withered	40·05	38·9	34·80	4·10	14·80	1·74
24 hours Withered	40·34	38·8	34·60	2·20	15·00	1·83
48 hours Fresh leaf	39·46	39·46	36·22	3·24	14·95	1·64
Withered	41·62	40·05	35·35	4·70	15·20	1·74
2 hours Withered	40·82	39·60	35·00	4·60	14·80	1·81

"In the same table figures, corrected for respiratory losses during withering, are also given of the alcohol soluble and alcohol insoluble substances, the tannin and the nitrogen content of the extract. From these it is apparent that the material soluble in alcohol diminishes in quantity during withering whereas the gummy substances insoluble in alcohol increases in amount. In the two instances given, the increase of the alcohol insoluble material amounts to 38 and 45 per cent., respectively. An increase of tannin also occurs during the first two days of withering, but if this process is prolonged to the third day, a decrease occurs.

"The amount of nitrogen in the extract also increases during withering. This increase probably results from hydrolysis of protein substances with the formation of amino acids. A prolonged wither, particularly at high temperatures, should therefore be avoided, as a degradation of protein substances is liable to sour the leaf and produce objectionably odoured substances. This, however, is a matter which will be investigated further.

"The Entomologist has been occupied mainly with the breeding of the egg parasite of Tortrix. The egg of the paddy grain moth has not proved a successful medium on which to raise the parasite, so a reversion is being made to the eggs of the maize moth.

Considerable difficulty is being experienced in increasing the stock of parasites at a satisfactory rate. To be of any use in controlling Tortrix in the

field, parasites will have to be liberated by the hundreds of thousands daily. Before this can be done, a laboratory stock has to be raised, and each generation must be at least twice as large in number as its predecessor. The latter requirement is essential in order that half of each day's outturn may be liberated without causing a depletion of the stock colony. As yet, this standard has not been maintained, but is is hoped that the use of the egg of the maize moth instead of that of the paddy moth will result in an improvement in this respect.

"It has been demonstrated that the parasites reared on grain moths' eggs will attack the eggs of the Tortrix moth. In the test, several Tortrix egg masses were parasitised to the extent of nearly 100 per cent. If the parasites can be raised in sufficient quantity, this promises well for a possible effective control by this method.

"Nettle grub has been reported from the Udapussellawa district and the evidence indicates that the insects have migrated from the Badulla district.

"Trials of various proprietary insecticides on Tortrix larvae have been continued. Tests with poison dusts have been carried out on bag worms and a species of Geometrid caterpillars found to attack Albizzias."

The Chairman said that 180 copies of the monthly reports were being sent out, and he asked Dr. Gadd if the publication of these reports caused the staff to curtail them.

Dr. Gadd replied in the affirmative, and added that the curtailment was possibly a consequence of publication.

After some discussion, it was decided to abandon the publication of the progress reports and, instead thereof, the Director will in future call for reports from the staff to enable him to write a quarterly review which will be published in the Tea Quarterly.

ST. COOMBS ESTATE.

The Chairman announced that the Institute had completed negotiations and taken possession of the St. Coombs Estate as from December 10th, and that Mr. Rogers had assumed duties as Superintendent from the same date.

The Board expressed its warm appreciation of the work the Chairman had put in in the negotiations for the estate.

The Chairman mentioned that the following machinery, etc., had been approved by the Estate sub-Committee and by the Board, by circular letter :—2 Jackson's Rapid Rollers, 1 Economic Roller, 2 Roll Breakers (C.C. Co.,), 2 T.T. Driers, 1 Davidson's Packer, 1 Michie Sifter, 1 Savage Cutter, 1 Compressor for Driers, 2 72" Fans, 4 60" Fans, 3 48" Fans, 1 15" Gunther Blower, 3 55-60 H.P. Tangye Engines.

The necessary sanction to place the orders for the above was given.

The Chairman stated that the Institute had been granted very moderate rates on all the machinery and that the institute was fortunate in having obtained them at such low rates.

The meeting confirmed the Chairman's action in accepting Messrs. Hemachandra and Co.'s tender to work and deliver sand at St. Coombs as well as for general transport.

The Chairman said that on the advice of the Estate sub-Committee, Chapelton and Norwood Estates had been asked and agreed to supply 10 maunds of tea seed each, early in 1929.

Mr. Horsfall said that he thought it might be possible to obtain light leaf Assam seed locally, and suggested that a few pounds should be purchased for experimental purposes.

It was decided to refer the question to Mr. Eden for an expression of his opinion.

Further consideration of the question of Superintendent's bungalow was deferred until the next meeting.

The Chairman asked the Board to approve of the plan of the small bungalows in order that the construction of one could be proceeded with at once and be available for the Superintendent to live in whilst the larger one he would eventually occupy, was being built.—The Board approved of this suggestion.

The Board approved of the plan and estimate of a temporary office and clerks' quarters, the building later to be used as a store for packing materials, etc.

NEW DIRECTOR.

The Chairman reported that Dr. A. W. Hill, Professor Farmer and Sir John Russell had accepted the invitation to form a Selection Board for the appointment of a new Director.

The Chairman suggested that Mr. Stockdale should be invited to join the Selection Board. The Colonial Treasurer seconded and the Board agreed to this proposal.

The Chairman stated that the question of the appointment of a plant physiologist had been referred to members of the Selection Board who had been asked to submit the names of suitable men.

The Chairman said that Dr. Small was agreeable to confer with Dr. Gadd on the matter of mycological work during acting appointment and suggested that the matter should be considered at the next meeting.—This was agreed to.

The Acting Director reported that 51 applications had been received for the post of Assistant to the Chemists. He proposed to interview the six candidates considered as most suitable in order that the one selected could take up duties as early in the New Year as possible.

Dr. Gadd's proposals were approved.

BOARD OF TEA RESEARCH INSTITUTE.

The Chairman reported that the Planters' Association and the Ceylon Estates Proprietary Association had re-elected their representatives to the Board of the Tea Research Institute, for a further period of three years.

The Low-Country Products' Association had elected the Hon. Mr. D. S. Senanayake in place of Col. T. G. Jayawardene.

Government had appointed Mr. T. B. Panabokke to represent the small-holders for a further period of three years.

The Members of the Board on January 1st, would be :—

P. A. Representatives :—Mr. R. G. Coombe (Chairman), Mr. John Horsfall, and Mr. D. S. Cameron.

C.E.P.A. Representatives :—Mr. P. A. Keiller, the Hon. Mr. J. W. Oldfield and Mr. J. D. Finch Noyes.

L.C.P.A. Representative :—The Hon. Mr. D. S. Senanayake.

Small-holders' Representative :—Mr. T. B. Panabokke.

Ex-Officio Members :—The Hon. the Colonial Treasurer, the Director of Agriculture, the Chairman P.A. of Ceylon, and the Chairman C.E.P.A.

The Chairman proposed that an expression of the Board's appreciation of Mr. Stockdale's services whilst a member of the Board of this Institute be recorded.—This was unanimously carried.

After some discussion it was decided that it would be very dangerous to allow the Rifle Range on St. Coombs Estate to continue to be used, and that notice be given that it should be closed as from February 1st, 1929.

MEETING OF BOARD OF TEA RESEARCH INSTITUTE.

A meeting of the Board of the Tea Research Institute of Ceylon was held in the Victoria Commemoration Buildings, Kandy, on Tuesday, January 8, 1929. There were present :—Mr. R. G. Coombe (Chairman), the Hon. the Colonial Treasurer (Mr. W. W. Woods), the Hon. Mr. J. W. Oldfield, the Hon. Mr. D. S. Senanayake, the Acting Director of Agriculture (Dr. W. Small), Messrs. E. C. Villiers, H. F. Parfitt, John Horsfall, T. B. Panabokke, P. A. Keiller, and A. W. L. Turner (Secretary), and, by invitation, Dr. C. H. Gadd (Acting Director, T.R.I.).

Letters and telegrams regretting inability to be present at the meeting were received from Messrs. D. S. Cameron and J. D. Finch Noyes.

The Chairman reported that the Estate sub-Committee had considered tenders for bungalows for the Superintendent and research staff that morning, with the Architect.

After a full discussion, it was decided, on the proposal of Mr. Woods, seconded by Mr. D. S. Senanayake, to refer the matter back to the sub-Committee for further consideration.

LABORATORIES.

The Chairman announced that the sub-Committee had also considered the plan, specification and tender for laboratories, but, owing to the Architect being unable to be present and to the lack of several important details, they were unable to make any recommendations.

The sub-Committee were requested to, if possible, submit their report to the next meeting.

Consideration of the appointment of a clerk of works was deferred, pending decisions being come to in regard to the buildings referred to in the two preceding paragraphs.

It was decided that a reservoir in the place of the proposed water tower should meet all requirements of the water service and be less costly.

The Chairman was authorised to sign the mortgage on the estate to Government when the deed had been drawn up by the Institute's legal advisers.

SCIENTIFIC STAFF.

The Chairman announced that the Department of Agriculture were, subject to the approval of Government, now agreeable to assist the Institute in its Mycological work during the time Dr. Gadd would be on leave.

The appointment of Mr. E. N. Perera as Assistant to the Chemist was announced.

The Chairman also announced that the Entomologist, Mr. Stuart Light, had tendered his resignation and steps had been taken with a view to filling the post when it became vacant on June 30th next.

The Board sanctioned the application of the Ceylon Association in London for 60 copies of the future issues of the Tea Quarterly.

It was also decided that all publications, issued by the Institute, should be sent to this body free of charge, as well as to Mr. Stockdale, late Director of Agriculture.

The Chairman reported that Mr. Ferguson, Visiting Agent, had recently paid his first official visit to the estate. It was decided that a copy of his report should be sent to each member of the Board.

FACTORY.

It was decided that an order for the electrical machinery required for the factory should be placed with the B. T. H. Co., through the Colombo Commercial Co.

DEPARTMENTAL NOTES.

PROGRESS REPORT OF THE EXPERIMENT STATION, PERADENIYA:

FOR THE MONTHS OF JANUARY AND FEBRUARY, 1929.

TEA.

THE result of the banji experiment alluded to in the last report was that after plucking 100 marked banjis 46 of the shoots again produced banjis from the axil of the next leaf while 54 shoots produced good flush. The theory that a shoot which produces a banji will, if that banji is plucked, always produce another banji thus cannot be maintained. The matter probably depends on the state of vigour of the bush.

The drought experienced during January and February was the worst for many years and resulted in the death of a considerable number of supplies. Another examination of the Hillside tea, where strips of *Indigofera endecaphylla* alternate with clean weedings, was made towards the end of the drought. Again there was no *marked* difference between the appearance of the tea under Indigofera and the clean-weeded tea, but the tea under Indigofera appeared slightly more vigorous. It also appeared that losses of supplies were more numerous in the clean-weeded tea.

RUBBER.

Wintering was very early this year. The majority of the trees had their new foliage by the end of February.

In the Hill-top rubber where during the north-east monsoon *Dolichos Hosei* was planted along the terraces, alternatively in forked patches and in holes specially filled with jungle soil, no result has been obtained by either method.

CACAO.

The annual lopping of dadaps followed by a light pruning of the cacao was carried out in January and February.

Treatment of bark canker by light scraping and painting with 10% Brunolinum Plantarium was done in January. No treatment was carried out last year and the increased incidence of canker this year demonstrates the need for regular treatment.

Another serious problem in cacao is the loss of shade through dadaps falling down. This is constantly occurring and results in considerable damage to cacao trees by breaking and subsequent deprivation of shade. The replacement of shade by planting fresh cuttings is a very slow operation. No root disease has so far been found on dadaps in cacao. Shallow rooting would appear to be a serious disadvantage of Erythrina as a shade for cacao.

COCONUTS.

All the young palms of different varieties in the fodder grass plots were manured with a mixture consisting of 2 parts groundnut cake, 2 parts of fish manure, 3 parts steamed bone meal, and 1 part sulphate of potash, applied in circular trenches at the rate of 9 lb. per palm.

FODDER PLANTS.

When grass ran short during the drought the cattle were fed for a fortnight on *Indigofera endecaphylla*. No other green food was given. All the Indigofera was invariably finished and the value of this plant as a fodder in times of drought is well worthy of note.

The Efwatakala grass in plot 167 has now been almost entirely superseded by couch and other grasses. It has certainly not fulfilled its early promise.

Guatemala grass which was planted in plot 160 in October last in place of *Paspalum commersonii* has come on very well indeed and has not been in the least affected by the drought.

CHAULMOOGRA OIL PRODUCING PLANTS.

All plants of *Hydnocarpus Wightiana* and *Taraktogenos Kurrzii* were given an application of nitrate of soda at the rate of 4 oz. per plant in January. Cheddy in this area was cut down.

THE IRIYAGAMA DIVISION.

On February 8th a sub-Committee of the Estates Products Committee consisting of the Acting Director of Agriculture, Major J. W. Oldfield, Messrs. C. E. A. Dias and T. H. Holland met to discuss the modification of the plans for planting this Division. The sub-Committee's recommendations have been embodied in a separate memorandum.

On February 11th the clearing of the remaining 20 acres of jungle was auctioned and the work is now in progress.

In September last all stumps in the budwood nursery were cut down, one bed to 1 foot, one bed to 6 inches, one bed to 2 inches, and so on. The percentages of stumps which have put out new shoots are as follows:

Cut down to 1 ft.	81%
,, ,, ,, 6 inches	65%
,, ,, ,, 2 inches	53%

All the remainder died. This would appear to emphasise the necessity of having young seedling stocks for budding on to since cutting down old stumps to 2 inches is likely to result in considerable losses. Cutting down to 1 ft, though possible in a budwood nursery, would not be feasible on trees to be tapped.

T. H. HOLLAND,
Manager,
Experiment Station, Peradeniya

REVIEWS.

THE ROYAL COMMISSION ON AGRICULTURE IN INDIA.*

IN April, 1926, a Royal Commission with Lord Linlithgow as Chairman was appointed to enquire into the condition of agriculture in India. The members of the Commission were men of such wide and deep experience of Indian agriculture and rural economy that their report was certain to be of the utmost value. The report* which was presented to Parliament in June 1928 has not disappointed expectations. The report (with the abridged report) is contained in a volume of over 750 pages and in the course of its preparation 783 replies to a questionnaire were received and 395 witnesses were orally examined in India and Great Britain. The evidence is contained in ten volumes totalling over 7,500 pages. The magnitude of the task of reporting on the condition of agriculture in India is obvious; these figures give some idea of the thoroughness with which the Commission set about its work.

Except for a brief account of the organization of agricultural research in Canada, Australia and the United States the report deals entirely, as is to be expected, with Indian conditions, but nevertheless it is of interest to all tropical countries where there is peasant farming and it is of particular interest to Ceylon. It is impossible here to discuss the report in anything like the detail it deserves, or even to indicate its scope, which is of the widest; attention, however, must be drawn to its excellence and to the applicability of many of its recommendations and conclusions to Ceylon village agriculture. By the many who are interested in this part of Ceylon agriculture the report will be welcomed and closely studied.

Conditions in India vary widely and are not always comparable with those in Ceylon but in the main the problems confronting village agriculture in the two countries are surprisingly alike. There are, for example, the same general problems of crop improvement, of the introduction of new methods and implements, of improvement of live stock, of indebtedness and credit facilities, and of the improvement of the health and education of the rural population.

Chapter IV of the report which deals with agricultural improvement deserves careful attention. After detailing the crops of India and their acreages and discussing the soil types met with the chapter proceeds to treat with the problem of improving the fertility of the soil by manuring. The problem needs much more investigation and "requires to be studied in three aspects, in relation, in the first instance, to the crops which are dependent solely on rainfall, in the second, to crops which are grown on irrigated land, and, lastly, to the planters' crops and intensive cultivation such as that of sugarcane and garden crops". The importance of the problem of manuring crops which depend upon a precarious rainfall is fully appreciated and it is stated that "we wish especially to emphasise the importance of manurial experiments on unirrigated land as the cultivator of such land, who runs, with his very limited financial resources, the risk of losing his crop in an unfavourable season, stands most in need of guidance in this matter". The Commission draws attention to the importance of preserving farmyard manure but realises that nothing can be done

* Report of the Royal Commission on Agriculture in India. H.M. Stationery Office, London, 1928. 11s. net.

unless an alternative fuel supply is available. In Ceylon generally there is nothing but the apathy or ignorance of the cultivator which stands in the way of conserving farmyard manure.

The question of the local manufacture of crushed bones and bone meal has lately been raised in the Batticaloa district where, if manuring paddy with steamed bone meal can be shown to be profitable, there is a large area under this crop which can be benefitted. In a discussion of the local production of bone meal by small mills in localities where sufficient supplies of bones are available it is stated that "a far more thorough investigation of the economics of the bone-crushing industry than has yet been carried out is, we consider, required before the establishment of such mills can safely be undertaken by private enterprise. The first essential is to obtain definite data in regard to the price at which, and the crops for which, the use of bone meal is advantageous to the cultivator". It is also necessary to make certain that an adequate supply of bones is assured.

One of the most important means of agricultural improvement is the introduction of superior strains or varieties of crops and it is said that this is the main success of agricultural departments in India. "The crops in which the greatest advance has been made are cotton, wheat, rice, groundnut and jute, but there is still very great scope for further work especially in regard to the millets, pulses and oil seeds". In Ceylon, also, these last three classes of crops are awaiting improvement. The abridged report in discussing the three methods of obtaining superior varieties states: "These are selection, hybridisation and acclimatisation. Of the three, selection seems to be the most hopeful line and that which offers the greatest immediate possibilities of effecting improvement in Indian conditions".

The problem of the distribution of the improved seed so evolved is no less important than the actual work of selection. Frequently it is more difficult. Most of the following remarks on this subject from the abridged report are applicable to Ceylon. "For many years to come it seems probable that the work of seed distribution will have to remain in the hands of the agricultural departments. But if seed merchants of proved enterprise should be forthcoming, they should be given every encouragement. In present conditions the co-operative agency seems to offer the best prospects of assistance to the agricultural departments in seed distribution though private seed agents, as distinct from seed merchants, might also be employed. They should be persons on whom the agricultural departments can rely and should deal only with seeds supplied by the departments in sealed bags or packets. Until reliable seed merchants come into the bussiness, the selection and distribution of pure seed should be controlled by the agricultural departments. It is not possible to lay down any rigid lines of policy. Departments must be guided by local conditions and must use such agencies as are available locally for the production and distribution of pure seed. But a considerable increase in the number of seed farms, both departmental and private, is very desirable".

Before any agricultural improvement which has been investigated and proved to be of utility by an agricultural department can affect agricultural practice it must be introduced to the cultivator in such a way as to persuade him of its benefits. "In a country in which illiteracy is so widespread as it is in India, ocular demonstration is the best method of convincing the cultivating classes of the advantages of agricultural improvement. But, before an improvement can be recommended for general adoption, it must be thoroughly tested on a government farm. It must be within the means of the cultivator to whom it is recommended and it must give a substantial

financial advantage either in increased outturn or in the reduction of his cultivation expenses. There are two methods of demonstration, the demonstration farm and the demonstration plot. Opinion is almost unanimous that the best and quickest method of influencing the practice of the cultivator is to demonstrate an improvement in crop or method on a small plot cultivated under departmental control or direction".

The Commission also points out the advantages of concentrating demonstration and propaganda work. In the introduction of an improved crop or variety this is very important. But it is of fundamental importance that no improved variety or method should be introduced to the cultivator before it has been thoroughly tested on government farms.

It will be instructive to give extracts from the report on two other major problems—credit facilities and public health. In India village agriculture is financed chiefly by money-lenders, partly by the network of co-operative credit societies which has been developed under the auspices of government, and to some extent by government loans under the Land Improvement and the Agriculturists' Loans Acts. In Ceylon the finance of village agriculture is almost entirely in the hands of money-lenders but in both countries indebtedness is the rule and the burden of debt is frequently severe. In the abridged report it is stated: "We have no hesitation in recording our belief that the greatest hope for the salvation of the rural masses from their crushing burden of debt rests in the growth and spread of a healthy and well-organized co-operative movement based upon the careful education and systematic training of the villagers themselves. Apart altogether from the question of debt, co-operative credit provides the only satisfactory means of financing agriculture on sound lines". But, lest the enthusiastic student of rural uplift think co-operative credit a simple panacea, the following remarks from the abridged report must be borne in mind. "The history of the Agricultural Bank of Egypt is, however, an instructive warning to those who hold that problems of rural debt are to be solved by the provision of cheap and abundant credit. In fact, cheap credit is a blessing to a rural population only where the average cultivator is possessed of the knowledge and strength of character required to induce him, on the one hand, to limit his borrowing within the range of his capacity to repay, and, on the other, to apply the greater part of the borrowed money to sound productive purposes."

The temptation to continue quoting is almost irresistible, but one more extract, on public health, must suffice. Public health, as the Commission points out, is one of the main factors affecting rural prosperity. "The close relationship between agriculture and public health is obvious and the two react upon each other to a remarkable degree. Economic wastage due to disease cannot be over-exaggerated. Malaria slays its thousands and lowers the economic efficiency of hundreds of thousands.....
.....Any enquiry, therefore, into the general condition of agriculture and the position of the cultivator must take account of the public health aspect of his life, of the suitability of his diet, of the sanitary conditions under which he lives and of his general rural environment." In parts of at least two provinces in Ceylon malaria may be classified as one of the main factors affecting rural prosperity.

This review can only very inadequately indicate the value of the report. Nothing has been said here of the organization of agricultural research, the subdivision of holdings, animal husbandry, forests, irrigation, communications and marketing, education, or rural industries and labour, to each of which the report devotes a chapter.—L. L.

SOILS AND FERTILISERS IN 1927.

IN "Agricultural Research in 1927" Sir E. J. Russell reviews the scientific and economic work carried out on soils and fertilisers during 1927. In addition to an account of the fertiliser situation and an outline of the results of agricultural research work in the British Isles during the period, the report embodies the results of agricultural experiments carried out in 1927 in Australia and New Zealand, which countries the author toured in 1928. Reference is also made to agricultural work in foreign and tropical countries in so far as it is of interest to agriculturists in the British Isles. In this summary, only the results of work which has a bearing on agriculture in the tropics will be dealt with. The following are topics which should be of interest to agriculturists in Ceylon generally.

The Effects of Superphosphate on Soil Reaction and Crops in Relation to Climatic Conditions. In this connection the author states: "There is an idea current among farmers that superphosphate makes the soil acid. The chemists have been unable to find any evidence of increased soil acidity. A considerable numbr of tests have been made by the Rothamsted staff in different parts of the country, but even the most delicate methods failed to reveal any increase in acidity that could possibly affect the crop. However the idea arose, it appears to be inaccurate." The same conclusion, that superphosphate is incapable of causing soil acidity, was arrived at by Kappen in 1926. This fact should be borne in mind by those recommending the use of superphosphate in manure mixtures for tea and paddy in Ceylon.

Another interesting point about superphosphate is that its effectiveness is greatly modified by seasonal and climatic factors. In Australia, it has been found with cereals that the worse the season the better in general is the response of the crop to superphosphate, and that it reduces the amounts of water needed by crops besides considerably increasing the yields. Again, experiments in India with paddy have shown that in years of deficient rainfall, superphosphate was particularly helpful in maturing the crop which would otherwise have suffered from a shortage of water."

Soil and Fertiliser Conditions as Affecting the Composition and Quality of Crops. The composition and quality of crops may be affected by soil and fertiliser conditions in two ways (1) by altering the rate and habit of growth, (2) by changing the composition of the crop. "The composition of a crop depends on the composition of the soil, which regulates the amount of a constituent in the whole crop, and on the conditions of growth, which determine whether the additional constituents will cause a corresponding increase in the crop. The *total amount* of any soil constituent in the crop depends on the total amount present in the soil." The old idea held by agricultural chemists that the analysis of a plant furnished a complete guide to its manurial requirements is incorrect, for "the plant has no power of choosing what is beneficial and rejecting what is useless; it absorbs some of every thing in the soil water, though not necessarily in the proportions in which they occur."

Factors Influencing the Percentage of Nitrogen and Phosphorus in the Crop. "The chief factors determining the amount of nitrogen in the crop are (1) the amount of nitrogen in the soil, (2) the time of sowing of the crop and the rainfall in the early part of the crop's growth." These two points apply to annuals, *e.g.*, barley. When a dressing of a nitrogenous fertiliser is given to a crop, the nitrogen thus added to the soil need not necessarily increase the nitrogen in the crop. If it produces more growth and an

increased crop, as it generally does, the additional nitrogen is distributed over the whole crop and its percentage may fall. In the case of barley, it has been found that small nitrogenous dressings increased the crop and not the percentage of nitrogen in the grain, but large dressings increased both crop and nitrogen content.

The same applies to the amount of phosphorus in the crop. It is well known that the soil and grass of fattening pastures contain more phosphorus than the soil and grass of non-fattening pastures. "In Hawaii, the phosphorus in the juice of the sugar cane was found to be greater on soils containing much phosphorus than on soils containing less. The addition of phosphatic fertilisers in amounts usual in practice may increase the crop, but does not usually increase the phosphorus content of the cane. This appears to hold for other crops as well. It is therefore a question of the amount of phosphorus added. A relatively large dressing of the fertiliser will probably affect both the yield and the percentage of phosphorus in the crop. There have been cases recorded of the simultaneous increase of crop and constituent. The increase of the phosphorus content of fodder crops is a point of great practical importance to stockbreeders in Ceylon. It has been found as a result of numerous analyses that our soils are dificient in phosphoric acid and that our grasses both cultivated and uncultivated suffer from a corresponding deficiency. The lack of sufficient phosphoric acid and lime in the diet of farmstock has been found to affect adversely the health and vitality of the animals. By the application of large quantities of phosphatic fertilisers, it is possible to increase both the amounts of fodder and the quantity of phosphorus in it and thus its value as a food for livestock. Another satisfactory remedy is to supply the animals with phosphorus in the form of licks.

In connection with the importance of minerals in animal nutrition, reference is also made to the work of Aston in New Zealand. Sheep in certain areas of that country suffer from a wasting, non-transmissible disease called "bush-sickness." The disease was ascribed to a deficiency in iron and can be treated by "administering iron to the animal in the form of iron ammonium citrate or by top dressing the pastures with sulphate of iron or spent oxide of iron."

The Economic Utilisation of Soil Moisture. "The soil water problem in dry districts can be met in four ways: (1) wherever possible and necessary by irrigation, (2) by reducing loss of water from the soil, (3) choosing varieties of crop that need very little water, (4) growing these crops in such a way as to minimise the amounts of water needed." As regards irrigation, serious difficulties are known to arise soon after irrigation begins. The land often becomes sterile as a result of the salts contained in the irrigation water which affect both plants as well as soils, especially clay soils containing replaceable sodium or underlain by pan. The surest methods of avoiding the trouble are, says the author, (1) to reduce the water to the minimum required for good growth; (2) to avoid seepage as far as possible by, *e.g.*, using concrete channels whenever necessary and practicable; (3) to keep the soil as permeable as possible by the use of gypsum, by green manuring, by occasional deep cultivation to break through any pan or impervious layer, and by maintaining an adequate system of drainage; (4) to keep the water table as low as possible. Even then salt patches may appear in unexpected places. Local investigations are then necessary.

Cultivation as a Means of Saving Soil Moisture.—In dry regions a bare fallow is a good method of saving soil moisture. This has been found to hold in the case of wheat in the dry regions of Australia. "The effect of the fallow is to keep down weeds, to maintain a mulch on the surface, and to increase

nitrification." Recent work, however, has shown that for certain soils a mulch is not advantageous.

The Effect of Seasonal Factors on Crops.—A fact of some importance to agriculturists in Ceylon, and one which might help to throw some light on yield figures of Ceylon crops, has been disclosed by agricultural research workers in Australia and Russia, viz., that in a wet season the amount of water taken by a crop (cereal) is less than in a dry one. "In a drought year cereals require 546 parts of water: in a moister year only 273. This means a double disadvantage during the dry seasons; the crops need more moisture and they have less. Work at Rothamsted has shown that both sunshine and rainfall affect the efficiency of fertilisers for crops to a very appreciable extent."

Soil Micro-organisms.—"The Rothamsted workers showed some years ago that bacteria of the soil are preyed upon by protozoa, especially amoebae. Recent work has shown that some bacteria are better food for the protozoa than others, causing more rapid multiplication, so that whenever they are present the protozoa increase greatly in number. When they are absent, the increase is much less. This discovery helps us to understand the great daily fluctuation in the numbers of amoebae and bacteria observed in field soils." Reference is also made to the work of Rege who has shown that some of the organisms responsible for the efficacious decomposition of organic matter in the soil grow best at fairly high temperatures (60°C). The conditions necessary for the decomposition of resistant organic materials were also indicated by this worker. The conversion of sawdust to artificial manure has not yet proved successful, but the problem is nearing solution. The slow decomposition in the soil of certain leguminous crops when compared with straw in spite of the high nitrogen contents of the former, has been shown to be due to their high lignin content. This is a matter of some importance to Ceylon planters. Green manures should not be left to get too woody before they are lopped. Working on paddy soils, Subrahmanyan showed that the production in these soils of ammonia, in which form paddy chiefly takes its nitrogen, is probably the result of enzyme action and not of micro-organic activity.—A.W.R.J.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 28th FEBRUARY, 1929.

Province, &c.	Disease	No. of Cases up to date since Jan. 1st. 1928	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	698	360	71	555	28	44
	Foot-and-mouth disease	10	...	10	...	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	1	...	...	1	...	..
	Rabies[3] (Dogs)						
Colombo Municipality	Rinderpest	1014	339	75	916	23	...
	Foot-and-mouth disease	1	...	1	...	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	10	5	...	...	...	10
Cattle Quarantine Station	Rinderpest	44	7	22	17	5	...
	Foot-and-mouth disease	7	7	7	...	...	...
	Anthrax	...	...	...	...	...	...
Central	Rinderpest	43	10	...	42	...	1
	Foot-and-mouth disease	411	169	250	2	159	...
	Anthrax	...	...	...	...	...	...
	Black Quarter						
	Rabies (Dogs)	7	1	...	6	...	1
Southern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	787	...	607	26	154	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis						
Northern	Rinderpest	4	...	3	...	...	1
	Foot-and-mouth disease	150	150	80	70	...	...
	Anthrax	...	...	...	...	...	...
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	8006	13	7851	155	...	...
	Anthrax	...	...	...	...	...	...
North-Western	Rinderpest	23	23	...	11	...	12
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	1	1	...	...	1	...
North-Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	26	...	26	...	...	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	303	139	216	1	85	1
	Anthrax	...	...	...	...	...	...
Sabaragamuwa	Rinderpest	58	24	19	36	2	1
	Foot-and-mouth disease	3297	1586	2327	67	903	...
	Anthrax	...	..	...	...	...	...
	Haemorrhagic Septicaemia	7	...	...	7	...	...
	Pleuro-Pneumonia (in Goats)						

G. V. S. Office,
Colombo, 22nd March, 1929.

G. W. STURGESS,
Government Veterinary Surgeon.

METEOROLOGICAL

FEBRUARY, 1929.

Station	Temperature: Mean Daily Shade	Temperature: Difference from Average	Mean Humidity	Mean amount of Cloud 0=clear 10=overcast	Mean Wind Direction during Month	Daily Mean Velocity	Rainfall: Amount	Rainfall: No. of Rainy Days	Rainfall: Difference from Average
	°	°	%			Miles	Inches		Inches
Colombo Observatory	79·0	0	78	5·4	NW	96	1·78	6	— 0·31
Puttalam	79·0	+1·0	74	3·7	NNE	113	0·57	4	— 0·72
Mannar	80·1	+0·7	72	4·8	NE	192	2·25	2	+ 0·92
Jaffna	78·2	—0·4	76	3·4	E	79	0	0	— 1·32
Trincomalee	79·0	+0·4	76	3·9	ENE	121	1·56	3	— 0·6
Batticaloa	77·8	—0·8	82	4·4	NW	180	7·33	7	+ 3·91
Hambantota	79·4	+0·3	76	4·0	ENE	295	1·29	4	— 0·13
Galle	79·4	0	80	5·8	Var.	108	5·14	7	+ 2·27
Ratnapura	81·0	—0·1	74	4·8	—	—	10·23	17	+ 5·78
Anu'pura	78·0	0	68	5·2	—	—	0·14	2	— 1·41
Kurunegala	80·3	+0·4	64	5·7	—	—	0·40	2	— 1·29
Kandy	76·4	+0·3	66	3·9	—	—	0·42	5	— 1·86
Badulla	70·3	—0·1	80	4·1	—	—	2·02	9	— 0·92
Diyatalawa	64·9	—0·3	72	6·0	—	—	1·95	6	— 0·40
Hakgala	60·8	+0·6	74	5·8	—	—	2.61	10	— 0·71
N.' Eliya	56·0	—1·5	72	5·6	—	—	2·52	7	+ 0·49

In the south-west of the Island, the rainfall has been, on the whole, above the average for the month. Elsewhere it has been generally below average, the most striking exception being a narrow coastal strip running south from Batticaloa. A number of stations, chiefly in the Northern, North-Western, and North-Central Provinces, had no rain at all during the month.

Only one station reported as much as 5 inches in any one day, Periyakulam recording 5·13 inches on the 7-8th.

Temperatures have, in general, shown no marked deviations from average. The minimum air temperature at Nuwara Eliya fell below freezing point on 5 days, the 24th-28th inclusive, the lowest reading recorded being 28·7, on the 24th.

The mean relative humidity has generally lain between 70% and 80%, three stations recording less than 70%. Wind velocities have been about normal, and wind directions usually between east and north. Barometric pressure has been below normal.

D. T. E. DASSANAYAKE,
for H. JAMESON,
Actg. Supdt., Observatory.